AD-E301340

(12)

DNA-TR-81-207

NUCLEAR ENVIRONMENTS AND EFFECTS RESEARCH FOR THE NATIONAL TRAINING CENTER

Science Applications, Incorporated
P.O. Box 2351
La Jolla, California 92038

2 December 1982

Technical Report

CONTRACT No. DNA 001-81-C-0273

APPROVED FOR PUBLIC RELEASE;
DISTRIBUTION UNLIMITED.

THIS WORK WAS SPONSORED BY THE DEFENSE NUCLEAR AGENCY
UNDER RDT&E RMSS CODE B385081466 V99QAXNF00013 H2590D.

Prepared for
Director
DEFENSE NUCLEAR AGENCY
Washington, DC 20305

UNCLASSIFIED

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER DNA-TR-81-207	2. GOVT ACCESSION NO. ADA140301	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) NUCLEAR ENVIRONMENTS AND EFFECTS RESEARCH FOR THE NATIONAL TRAINING CENTER		5. TYPE OF REPORT & PERIOD COVERED Technical Report
		6. PERFORMING ORG. REPORT NUMBER R:LJF-82-004
7. AUTHOR(s) David L. Erickson, Julius F. Ickler, Irving B. Osofsky		8. CONTRACT OR GRANT NUMBER(s) DNA 001-81-C-0273
9. PERFORMING ORGANIZATION NAME AND ADDRESS Science Applications, Incorporated P.O. Box 2351 La Jolla, California 92038		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Task V99QAXNF-00013
11. CONTROLLING OFFICE NAME AND ADDRESS Director Defense Nuclear Agency Washington, DC 20305		12. REPORT DATE 2 December 1982
		13. NUMBER OF PAGES 86
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)		15. SECURITY CLASS (of this report) UNCLASSIFIED
		15a. DECLASSIFICATION DOWNGRADING SCHEDULE N/A since UNCLASSIFIED

16. DISTRIBUTION STATEMENT (of this Report)

Approved for public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

This work was sponsored by the Defense Nuclear Agency under RDT&E RMSS Code B385081466 V99QAXNF00013 H2590D.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Army	Nuclear Warfare
Chemical Warfare	Simulator
Engagement Simulation	Tactical
Field Exercise	Training
NTC	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This research provides a concept for enhancing nuclear warfare training in the Army National Training Center (NTC). A mission analysis, based on current doctrine and Army publications, determines the training requirements. Training functions are identified which are needed to satisfy the training requirements. Alternative concepts are developed which provide the training functions. Constraints are identified and measures for evaluating alternatives are selected. Concepts are evaluated and a recommended training system, consisting of hardware, software, and personnel is provided.

SUMMARY

The purpose of this research is to provide a concept for enhancing nuclear warfare training in the NTC. The approach is mission oriented, starting with an analysis which determines the requirements for nuclear warfare training at the NTC. The analysis is based on current doctrine and Army publications. Training functions are identified which are needed to satisfy the training requirements.

Alternative concepts are developed which provide the training functions. Constraints are identified and measures for evaluating alternatives are selected. Concepts are evaluated and a recommended training system, consisting of hardware, software, and personnel is provided.

PREFACE

This work is performed under terms of DNA contract number DNA 001-81-C-0273, 14 August 1981 for "Nuclear Environment and Effects Research for the National Training Center.

Conversion factors for U.S. customary
to metric (SI) units of measurement.

To Convert From	To	Multiply By
angstrom	meters (m)	1.000 000 x E -10
atmosphere (normal)	kilo pascal (kPa)	1.013 25 x E +2
bar	kilo pascal (kPa)	1.000 000 x E +2
barn	meter^2 (m^2)	1.000 000 x E -28
British thermal unit (thermochemical)	joule (J)	1.054 350 x E +3
cal (thermochemical)/cm^2 ****	mega joule/m^2 (MJ/m^2)	4.184 000 x E -2
calorie (thermochemical) ****	joule (J)	4.184 000
calorie (thermochemical)/g****	joule per kilogram (J/Kg)*	4.184 000 x E +3
curie ****	giga becquerel (GBq)**	3.700 000 x E +1
degree Celsius ***	degree kelvin (K)	$t_K = t^o{}_C + 273.15$
degree (angle)	radian (rad)	1.745 329 x E -2
degree Fahrenheit	degree kelvin (K)	$t_K = (t^o{}_F + 459.67)/1.8$
electron volt****	joule (J)	1.602 19 x E -19
erg****	joule (J)	1.000 000 x E -7
erg/second	watt (W)	1.000 000 x E -7
foot	meter (m)	3.048 000 x E -1
foot-pound-force	joule (J)	1.355 818
gallon (U.S. liquid)	meter^3 (m^3)	3.785 412 x E -3
inch	meter (m)	2.540 000 x E -2
jerk	joule (J)	1.000 000 x E +9
joule/kilogram (J/Kg) (radiation dose absorbed) ****	gray (Gy)*	1.000 000
kilotons ****	terajoules	4.183
kip (1000 lbf)	newton (N)	4.448 222 x E +3
kip/inch^2 (ksi)	kilo pascal (kPa)	6.894 757 x E +3
ktap	newton-second/m^2 (N-s/m^2)	1.000 000 x E +2
micron	meter (m)	1.000 000 x E -6
mil	meter (m)	2.540 000 x E -5
mile (international)	meter (m)	1.609 344 x E +3
ounce	kilogram (kg)	2.834 952 x E -2
pound-force (lbf avoirdupois)	newton (N)	4.448 222
pound-force inch	newton-meter (N·m)	1.129 848 x E -1
pound-force/inch	newton/meter (N/m)	1.751 268 x E +2
pound-force/foot^2	kilo pascal (kPa)	4.788 026 x E -2
pound-force/inch^2 (psi)	kilo pascal (kPa)	6.894 757
pound-mass (lbm avoirdupois)	kilogram (kg)	4.535 924 x E -1
pound-mass-foot^2 (moment of inertia)	kilogram-meter^2 (kg m^2)	4.214 011 x E -2
pound-mass/foot^3	kilogram-meter^3 (kg/m^3)	1.601 846 x E +1
rad (radiation dose**** absorbed)	gray (Gy)*	1.000 000 x E -2
roentgen ****	coulomb/kilogram (C/kg)	2.579 760 x E -4
shake	second (s)	1.000 000 x E -8
slug	kilogram (kg)	1.459 390 x E +1
torr (mm Hg. 0^o C)	kilo pascal (kPa)	1.333 22 x E -1

* the gray (Gy) is the accepted SI unit equivalent to the energy imparted by ionizing radiation to a mass of energy corresponding to one joule/kilogram.

**The becquerel (Bq) is the SI unit of radioactivity; 1 Bq = 1 event/s.

***Temperature may be reported in degree Celsius as well as degree kelvin.

****These units should not be converted in DNA technical reports; however, a parenthetical conversion is permitted at the author's discretion.

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

TABLE OF CONTENTS (continued)

SECTION PAGE

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (continued)

LIST OF ILLUSTRATIONS (continued)

SECTION 1
INTRODUCTION

1-1 BACKGROUND

The National Training Center (NTC) provides for battalion task force sized force-on-force engagement exercises. The latest technological developments are used in a computer based system to provide realistic exercise monitoring, control, recording, and interaction without obvious interference and artificial control measures. Battalions will be periodically cycled through the NTC in what will be their most comprehensive training experience at the battalion level. The NTC range extends over approximately one thousand square kilometers at Fort Irwin, California. The Phase I NTC was operational in January 1982 for 125 instrumented "players". "Players" generally are Blue Force (BLUEFOR) or Opposing Force (OPFOR) vehicles, e.g., tanks, armored personnel carriers (APC's), etc. in the field, although capabilities also will exist for a limited number of man-packs. The current version provides for 500 players and associated personnel.

NTC uses a combination of continuous radio frequency position locations of players and computer based calculation, storage and displays. Engagements are simulated by laser "firings". Recorded engagement outcomes, storage of unit and individual histories of condition and location, and various presentations of statistical and map data, provide control personnel with an up-to-date and convenient basis for realistic control and evaluation of the exercise. These data and displays also provide highly graphical after action reviews (AARs) and a permanent audio-visual training record for future analysis at home stations.

The NTC Phase I Instrumentation System does not have a comprehensive integral nuclear or chemical warfare capability, although the basic design concept incorporates the flexibility to accommodate NBC effects in the future. Currently, simple nuclear and chemical warfare events are operationally included, providing very limited training in nuclear and chemical warfare.

1-2 PURPOSE

The research performed under this contract provided a concept for enhancing nuclear warfare training in the NTC. The enhancements are designed to be consistent with, and to capitalize on, the current capabilities of NTC. Design alternatives are provided and compared, and a concept is recommended.

1-3 ORGANIZATION OF REPORT

Section 2 briefly describes the analytic methodology and then provides the results for each step in the methodology. Section 3 summarizes the results and provides a recommended operational concept and design alternatives which will provide the structure upon which to conduct training in a nuclear battlefield environment and satisfy existing training requirements of the Army.

SECTION 2
RESULTS

2-1 OVERALL APPROACH

The study used a mission driven study approach as shown in Figure 2-1.

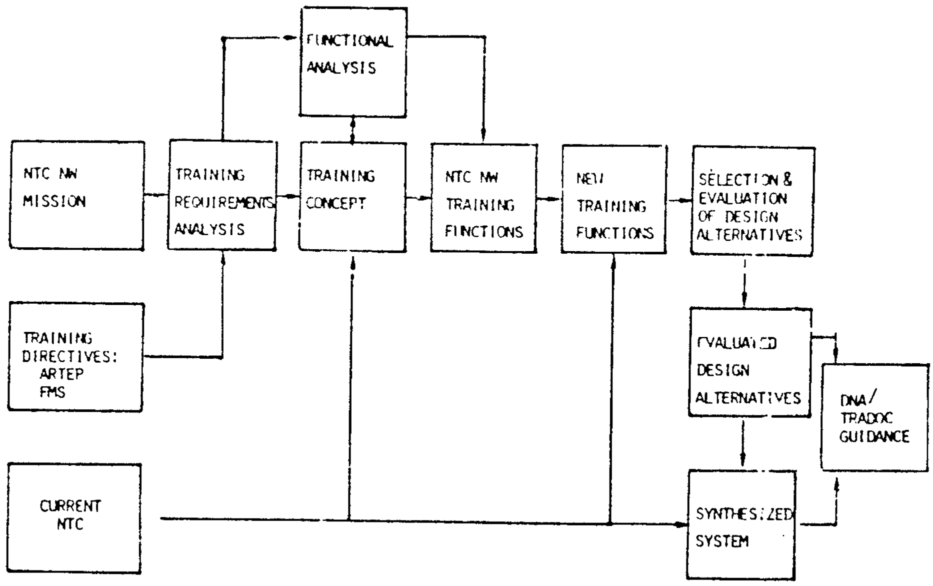


Figure 2-1. Mission driven study approach

Inputs consisted of the NTC Nuclear Warfare mission, training directives such as ARTEP 71-2 and guidance from the user. Using these inputs, a training requirements analysis was conducted to identify the training requirements for the National Training Center Nuclear Warfare capability. These requirements were then used to perform a functional analysis and also to identify a training concept. This concept was used to identify the training functions which were required by the NTC Nuclear Warfare Training System. The needed training functions were compared with the characteristics of the current NTC to identify new, NTC unique, training functions. The training functions were then analyzed to identify design alternatives. These design alternatives were evaluated on the basis of desired system characteristics. The simplistic scale consisting of excellent, good, fair, and poor ratings with associated values of 4, 3, 2, and 0 was used in the ratings. The

Design alternatives, with their ratings, are furnished to DNA and TRADOC for their use in selecting or recommending design alternatives to be used in further development. While it is possible that these agencies may rate functions differently, or use their own rating system and rating factors, the overall ratings used to derive design recommendations serve as a useful guide. An overall synthesized system has also been furnished based on selecting alternatives which are complimentary with one another and existing NTC architecture.

2-2 ANALYSIS OF TRAINING REQUIREMENTS

Training requirements were analyzed using the Requirements Tracing Tool (RTT). RTT is a software tool originally designed for tracing requirements between the various levels of specifications. It provided a ready-made means of recording and relating information on the training requirements in the NTC Nuclear Warfare Training System. Each document had a different series of numbers which identified the source of requirements. Key words were assigned to each requirement to assist in relating and recalling information. By the use of key words, the RTT provided a valuable tool for analyzing requirements with respect to any attribute of interest. The RTT data base has been saved so that reports can be generated to recall additional requirements based on any key word, or set of up to four key words.

It was found that all training requirements could be placed in the eight major training categories, or situations, contained in ARTEP 71-2. These eight major training requirements categories are as follows:

- Prepare for operations in a nuclear environment
- Prepare for nuclear attack
- React to initial effects
- React to delayed effects
- Cross, or operate in, contaminated area
- Conduct radiological reconnaissance
- Prepare for BLUEFOR nuclear strike
- Decontaminate

The training categories were used to postulate a training concept model which would satisfy all training requirements and were also used as the basis of functional analysis to determine the functions that needed to be incorporated in the NTC Nuclear Warfare Training System.

2-3 TRAINING CONCEPT MODEL

The training concept model which was postulated to satisfy the eight major training requirements and provide a consistent operation with the current National Training Center is shown in Figure 2-2.

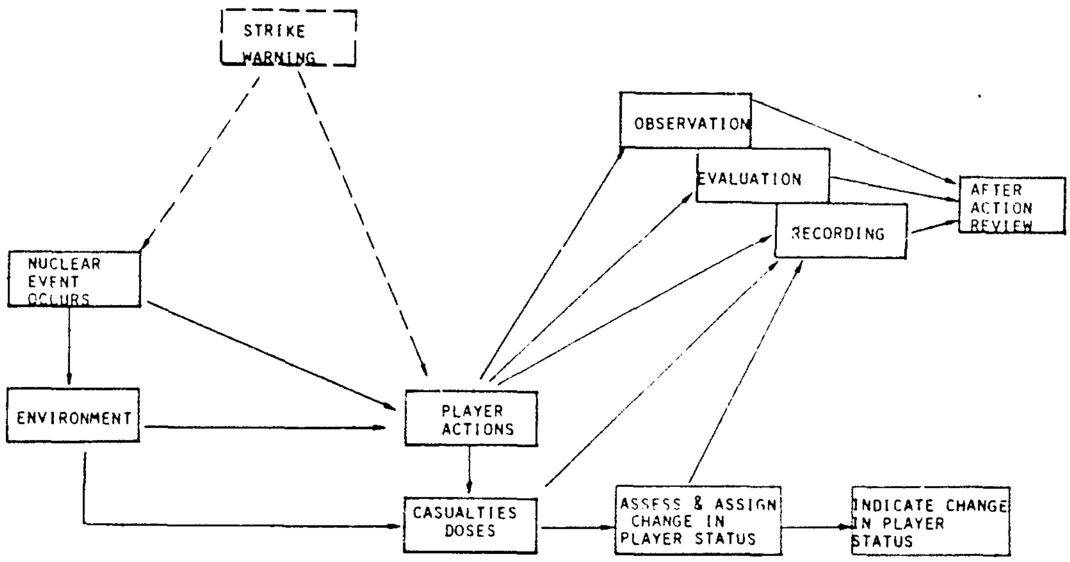


Figure 2-2. Postulated training concept model

For a Blue Force nuclear strike, the model begins with the strike warning. Strike warning is furnished by higher headquarters to the player unit. Following the strike warning a nuclear event occurs which is observed by the players. From the nuclear event an environment is generated. The strike warning and the nuclear event stimulate player actions. The environment, as observed by the players on meters or other appropriate means, also stimulates player actions. The environment produces casualties as well as accumulated doses in the players. Player actions are observed, evaluated, and recorded. Casualties and cumulative doses are also recorded. Changes in player status are assessed and assigned.

Throughout this report <u>assessed</u> is used to mean determining the number of casualties and fractional damage which occur. <u>Assigned</u> is used to mean determining specific players which are casualties or have incurred damage. <u>Indicate</u> will be used to mean showing which players are casualties or have incurred damage so that the other players can recognize that this damage has occured.

After casualties are assessed and assigned, changes in player status are also indicated. The results of the observation, evaluation, and recording are used, as appropriate, in after action reviews. The training concept model, combined with the training requirements, provided a top level idea of the functions which would be required.

2-4 FUNCTIONAL ANALYSIS

For each requirement, a flow chart was created which identified and related the functions needed to satisfy that requirement. The functions were then further analyzed to identify those which could be performed by the current NTC with little or no modification, and to identify those which would require new development. Analysis of the eight requirements is discussed below.

2-4.1 Prepare for Operations in a Nuclear Environment

The functional flow chart for this requirement is shown in Figure 2-3.

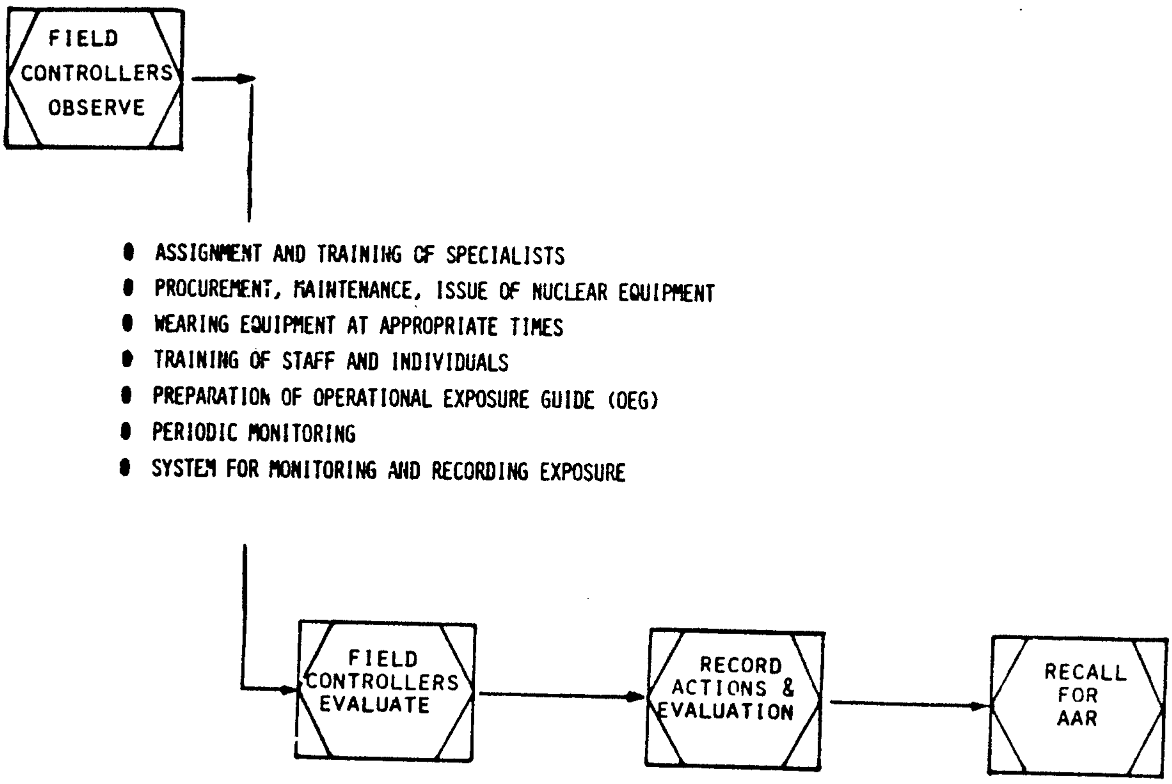


Figure 2-3. Functional analysis: prepare for operations in a nuclear environment

As shown in this chart, field controllers observe the preparations for the operations. These preparations consist of assignment and training of specialists, procurement, maintenance, issue of nuclear ‿quipment, wearing equipment at appropriate times, training of staff and individuals to prepare them for nuclear warfare, preparation of the operational exposure guide (OEG) by the approporiate staff officers, periodic monitoring at the appropriate times and existence of a system for monitoring and recording exposure. The field controllers evaluate the units based on these observations and record the actions and evaluations of the units. This information must be available for recall for use in after action reviews. Note that lines across the corners of the blocks denote functions which can be accomplished with limited modifiation of current software and/or additional hardware of the current type.

2-4.2 Prepare for Nuclear Attack

A functional flow chart for this requirement is shown in Figure 2-4.

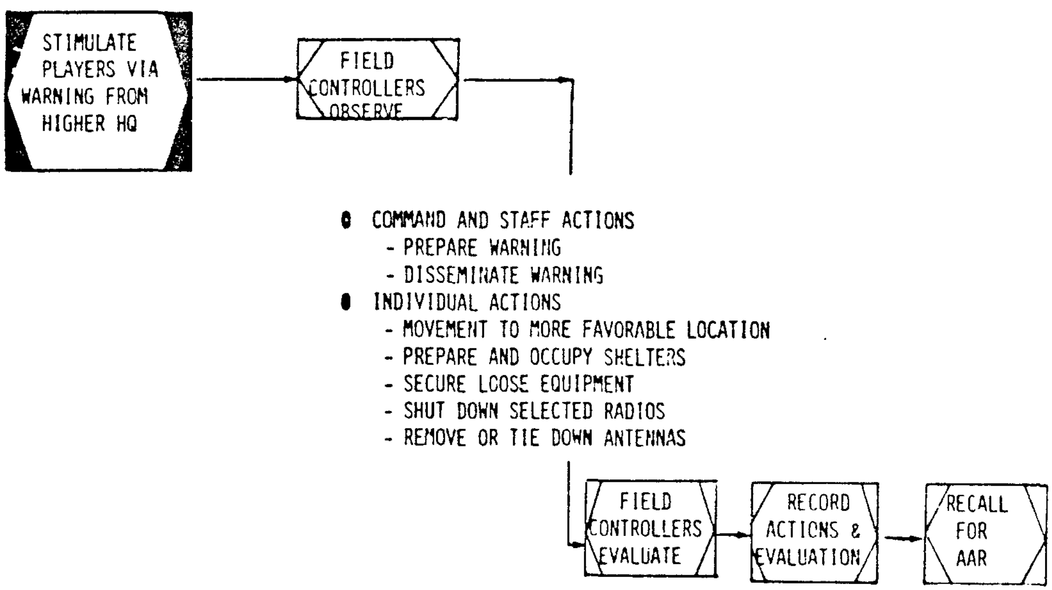


Figure 2-4. Functional analysis: prepare for nuclear attack

The first function is to stimulate players via a warning from higher headquarters. This is accomplished using the existing controllers at the central control station which represent higher headquarters. Note that blackened corners of the box represent functions which can be fully accomplished using the current National Training Center.

Field controllers observe command and staff actions including preparation of warning messages by commanders and the staff, and dissemination of warning to subordinate units and individuals. Field commanders also observe individual actions to include movement of individuals, crews and vehicles to more favorable locations where they will be sheltered from the nuclear blast, preparation and occupation of shelters, securing loose equipment by storing it inside vehicles or tying it down, shutting down selected radios to make them less vulnerable to electromagnetic pulse, and removing or tying down antennas to prevent them from being broken by blast. Field controllers evaluate these actions and record the actions taken and their evaluation. Actions and evaluations are recalled as required for after action reviews.

2-4.3 React to Initial Effects

The flow chart for this requirement is shown in Figure 2-5.

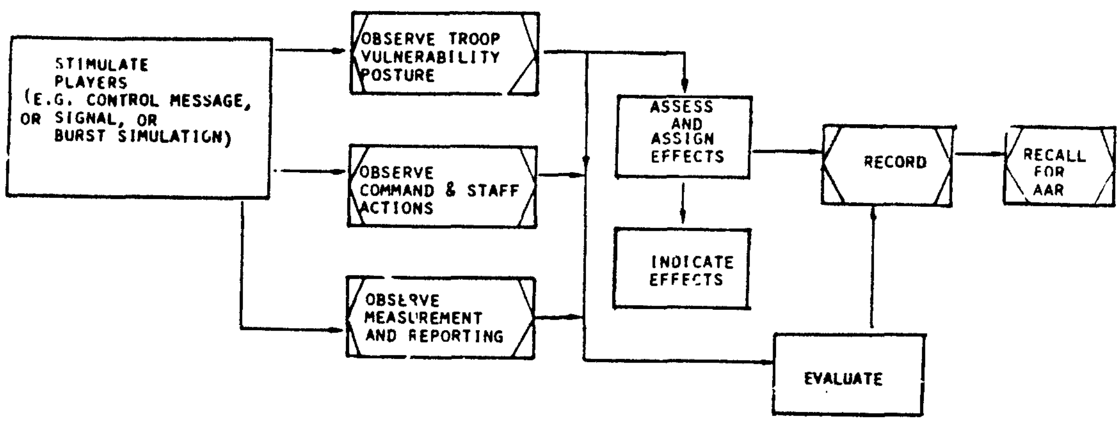


Figure 2-5. Functional analysis: react to initial effects

The first function in this requirement is to stimulate players to tell them that a nuclear burst has occurred. This can be accomplished using a control message (sending out a radio message that a nuclear burst has occurred) or a signal,(for example, a red star cluster which has been predetermined to represent a nuclear detonation) or a burst simulation which produces many of the characteristics of a nuclear burst. Following this stimulation, controllers observe the troop vulnerability posture. They observe the command and staff actions and observe the measurement of cloud dimensions and distance and reporting by individuals charged with that duty. The observation of the troop vulnerability posture is used in assessing and assigning effects. For example, the effects would be less on troops in tanks than those standing on the ground. After effects have been assessed and assigned they are indicated (using the definition for assess, assign, and indicate described in

Section 2-3). Effects are then recorded and the observations are then evaluated. Evaluations are also recorded. The information which has been recorded is available for recall for use in after action reviews.

2-4.4 React to Delayed Effects

The functional flow for this requirement is shown in Figure 2-6.

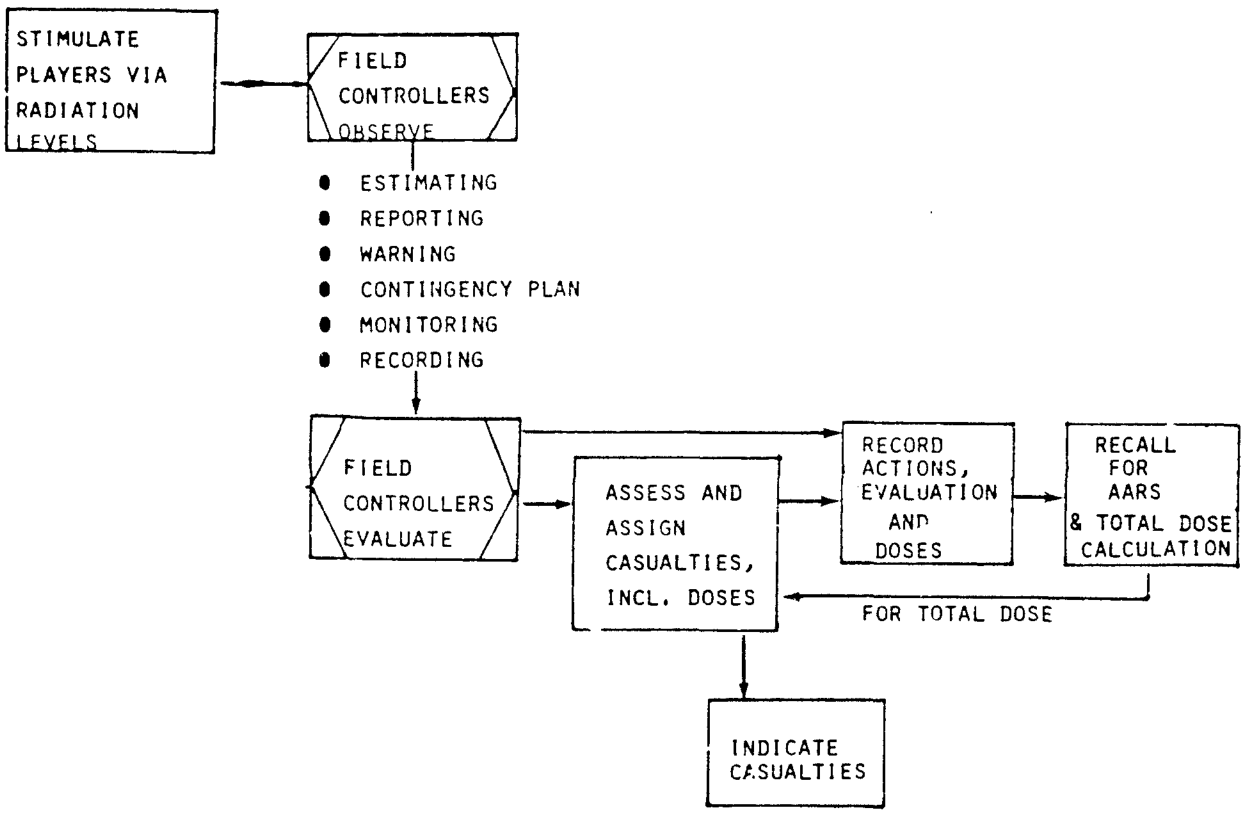


Figure 2-6. Functional analysis: react to delayed effects

The first function is to stimulate players via radiation levels so that the players will have a basis for reacting. Field controllers then observe the estimating of the radiation patterns, reporting of the radiation patterns to higher, lower and adjacent units, warning units of the existence of radiation, implementation of contingency plans to reduce the effects of radiation, monitoring procedures, and recording of radiation levels. The field controllers evaluate all of these actions and record the actions and evaluations. Based on the field controllers evaluation of the steps taken to protect against delayed effects, casualties are assessed and assigned and cumulative doses are determined for each player. Players may be aggregated

by crews or platoons or some similar level. The recorded information is recalled as required for AARs. Doses are combined to provide total dose. Total dose consists of both the dose received due to delayed effects and dose due to prompt radiation. Total doses are fed back into assessments and assignment of casualties. Casualties are indicated based on the assessment and assignment.

2-4.5 Cross or Operate in a Contaminated Area

The functional analysis for this requirement is shown in Figure 2-7.

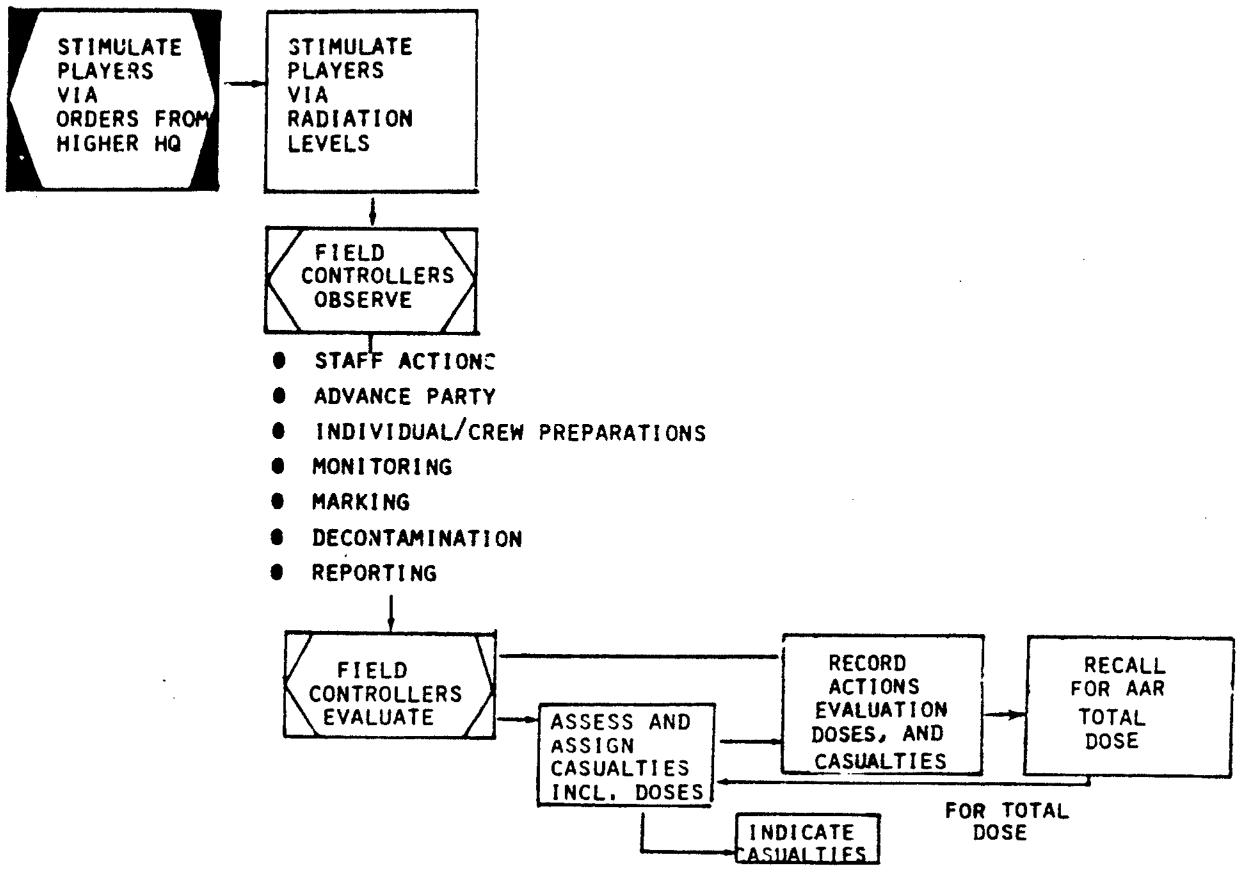


Figure 2-7. Functional analysis: cross (or operate in) contaminated area

The first function in this requirement is to stimulate players to take the appropriate action either to cross or operate within the contaminated area. There are two methods of stimulating their actions. One is via orders from higher headquarters. The second is to cause the players to react and perform the crossing or operating in the contaminated area by simulating radiation levels. Field controllers then observe staff actions to prepare for crossing the

contaminated area or staff actions directing precautions for operating in a contaminated area. They also observe the use of an advance party to mark the best way to cross the area, individual and crew preparations for crossing the area, monitoring, marking of routes through contaminated areas, decontamination following the crossing, reporting contamination and results of monitoring. Field controllers evaluate these actions. Their evaluations and observations are used in assessing and assigning casualties including total doses. Evaluations and observed actions are also recorded as well as the total radiation doses. This information is recalled as required for after action reviews and for total dose calculations. Total dose calculations are in turn fed back in to the assessment and assigning of casualties. Casualties due to radiation are also indicated so that players are aware that these casualties have occurred, when such effects would realistically be obvious.

2-4.6 Conduct a Radiological Reconnaissance

The functional analysis for this requirement is shown in Figure 2-8.

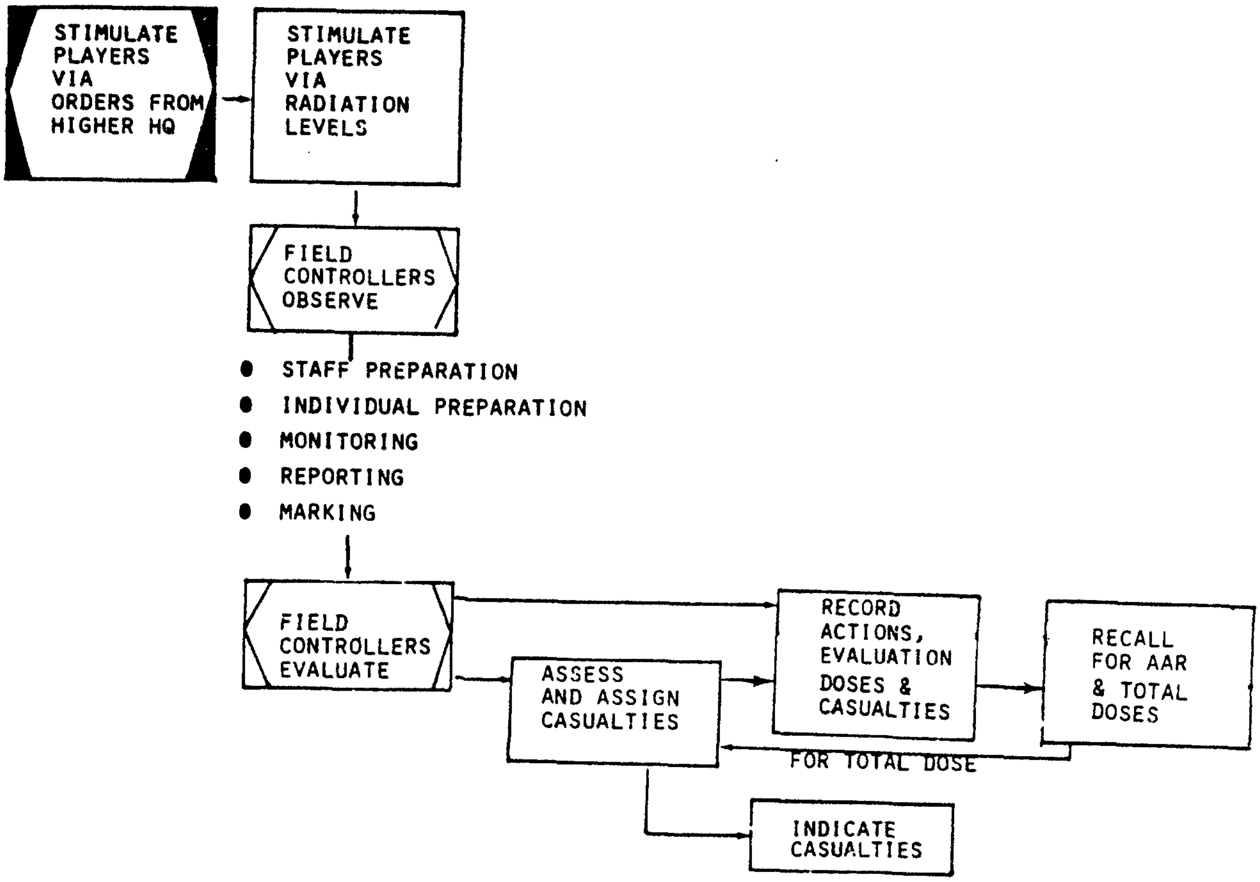


Figure 2-8. Functional analysis: conduct a radiological reconnaissance

The first function in this requirement is to stimulate players via orders from higher headquarters. The orders to conduct a radiological reconnaissance give the necessary information as to location of the reconnaissance and objectives to be accomplished. In addition, players are stimulated via radiation levels so that their actions are dependent on the radiation levels involved. Field controllers observe the staff preparation including selection of units to conduct a reconnaissance and providing necessary information on how the reconnaissance is to be carried out. Controllers also observe individual preparations as well as actions and orders of all levels of command and staff. Field observers accompany the reconnaissance group and observe their monitoring, reporting, marking of routes, marking of contamination levels, and other responsibilities of the team making the reconnaissance. Field controllers then evaluate the performance of the players making the reconnaissance. Their evaluation is used in assessing and assigning casualties. Their evaluation is also recorded along with doses, cumulative doses, and casualties as a result of nuclear

radiation. Actions and evaluations are available for after action reviews. Doses and other information provided the reconnaissance group is also available for the after action reviews. Total dose is fed back into the function of assessing and assigning casualties. The function of indicating casualties is also a necessity in this training requirement.

2-4.7 Prepare for Blue Force Nuclear Strike

The functional analysis for this requirement is shown in Figure 2-9.

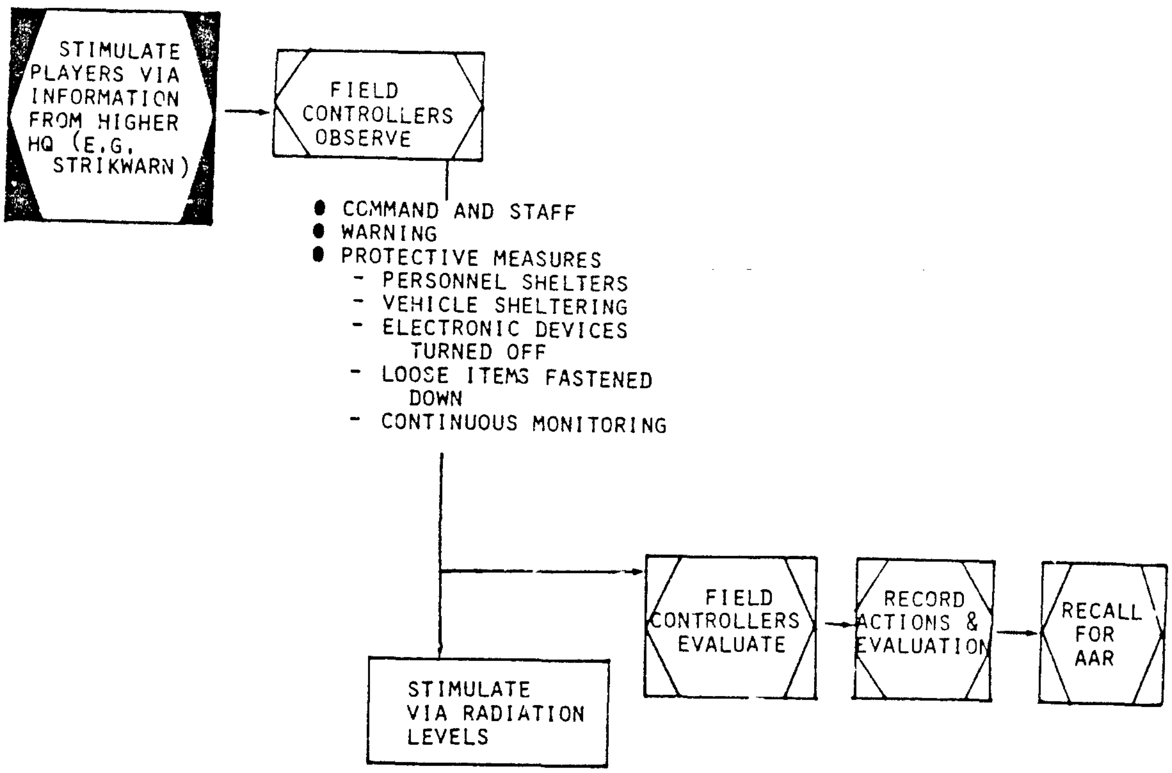


Figure 2-9. Functional analysis: prepare for Blue Force nuclear strike

The first function, as in the preceeding requirement, is to stimulate players via information from higher headquarters. In this case the information appears in the form of a strike warning. Field controllers observe command and staff actions at all levels to include warning of subordinate units and troops and direction as to what is to be done to protect against the Blue Force nuclear strike. Controllers also observe protective measures to include preparation and occupation of personnel shelters, sheltering of vehicles by

orienting them in the best direction relative to the blast, positioning vehicles in defilade, buttoning up vehicles at appropriate times, turning off electronic devices to reduce damage due to the electromagnetic pulse, fastening down loose items, removing or tying down antennas and continuous monitoring at appropriate intervals. As inputs to this continuous monitoring, there is a functional requirement to stimulate players via radiation levels which may exist before the blast occurs. Field controllers will evaluate the actions which they have observed and record the actions and their evaluation. The recorded actions and evaluations should be available for recall for after action reviews.

2-4.8 Decontaminate

The functional analysis for this requirement is shown on Figure 2-10.

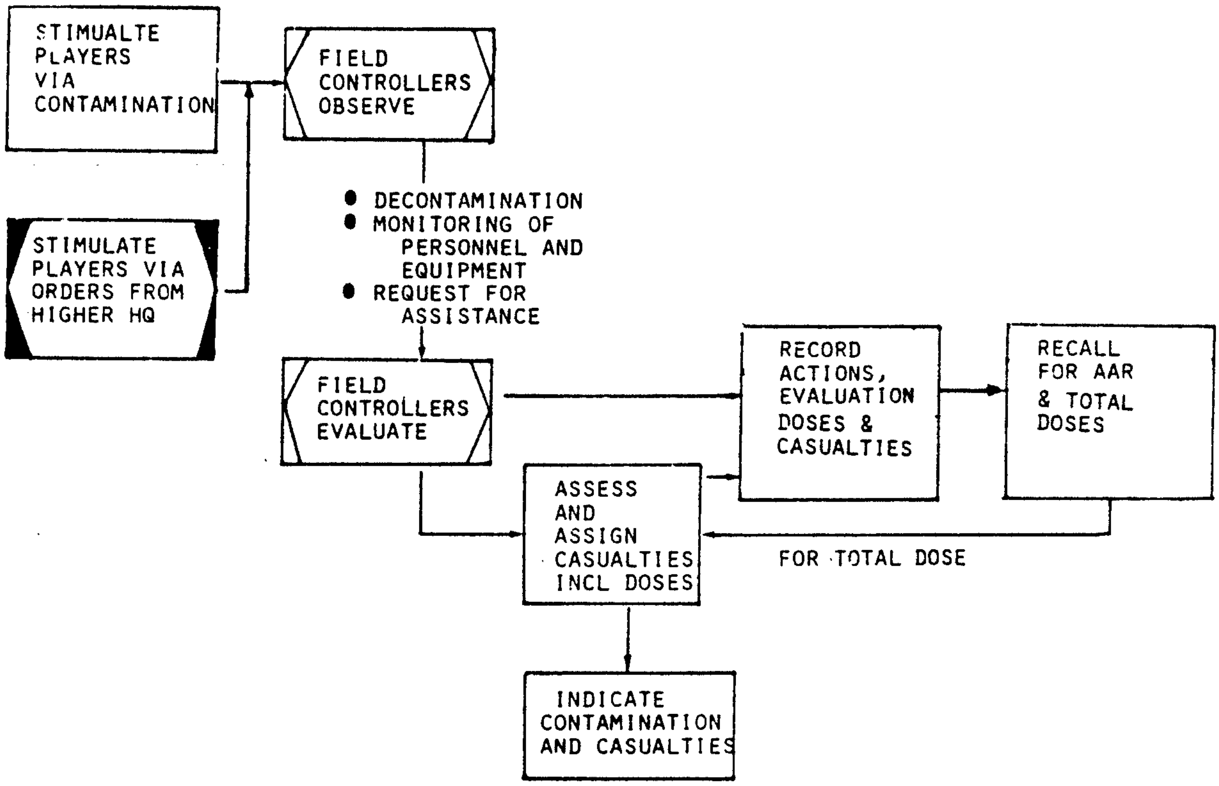


Figure 2-10. Functional analysis: decontaminate

For this training requirement players are stimulated by orders from higher headquarters to decontaminate and/or by a determination by commanders that decontamination is required, based on their observation of contamination levels. Field controllers will observe the decontamination

procedures including the clearing away of contaminated dust, monitoring of personnel and equipment to assess the effectiveness of the decontamination, and protection of personnel who are conducting the decontamination. They will also monitor any requests for assistance by decontamination teams. Observations of field controllers of exposure of personnel participating in the decontamination will be used to assess and assign casualties as well as calculate total doses. Field controllers' observations, evaluations and actions of players will be recorded as well as the doses and the casualties. This information will be available for recall for after action reviews and doses and casualties will be input to the assessment and assignment of casualties. As in previous training requirements the function of indicating contamination and casualties is also required in the decontamination training requirement.

2-4.9 Summary of Results of Functional Analysis

Functional analysis identified the training functions required to have nuclear warfare training implemented to a satisfactory degree at NTC. The results of the functional analysis is summarized in Figure 2-11.

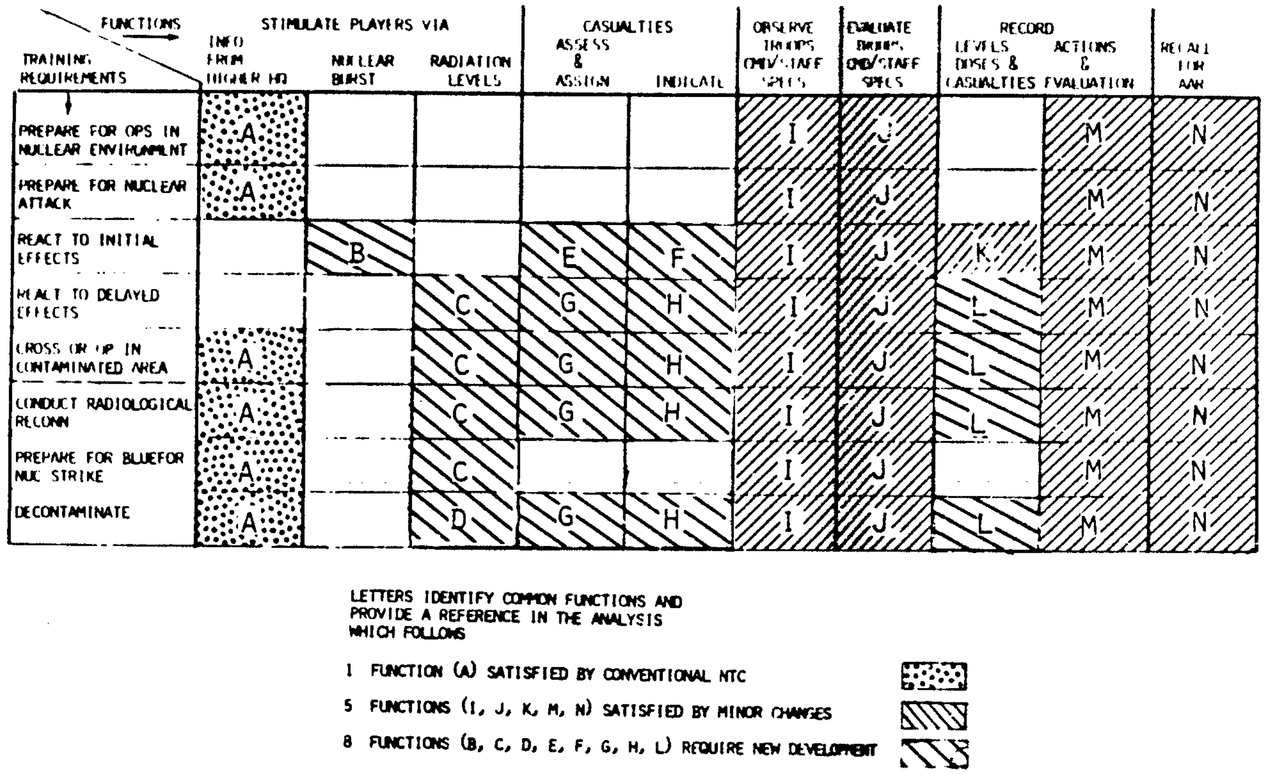


Figure 2-11. Results of functional analysis

The column on the left shows the eight training requirements which have been identified. Across the top are shown the functions which are required to satisfy these training requirements. Where there is a function required for any given requirement, the block at the intersection of the function and requirement is filled in. There are three different levels of implementation shown. One indicates the function is satisfied by the conventional NTC. One indicates functions which can be satisfied with minor changes, either in software, additional personnel responsibilities or in addtional hardware of the current type. The third category indicates functions that require new development. In general, functions consist of stimulating players, assessing, assigning and indicating casualties, observing and evaluating, recording and recalling for after action reviews. Functions are labeled with a letter, A, B, C, etc. Functions which are the same have the same letter even though they may refer to a different training requirement. These letters are used later in the analysis of design alternatives to satisfy the function.

One function (A) is satisfied by the existing conventional NTC. This function consists of stimulating players by information including orders from higher headquarters. Five functions (I, J, K, M, N) are satisfied by minor changes. These functions consist of observing troops, commanders, staff and specialists, evaluating these players, recording initial casualties, recording actions and evaluations, and recalling for after action reviews. Casualties due to initial effects will not be cumulative so that in function K these casualties can be recorded in the same manner as casualties due to conventional weapons.

Functions B, C, D, E, F, G, H, and L require new development. Function B consists of stimulating players via a nuclear burst to satisfy the requirements to react to initial effects. A nuclear burst simulator is locally manufactured and utilized in the live fire exercises at the NTC at the present time. However, this simulator is judged to be lacking in realism, and, as will be seen in subsequent analysis, does not satisfy all the requirements of this function. Function C stimulating players via radiation levels, which is used in the training requirements of reacting to delayed effects, crossing or operating in the contaminated area, conducting a radiological reconnaissance, preparing for a Blue Force nuclear strike, and decontaminating is currently provided at the National Training Center. Again, this function is lacking in the capability of recording radiation patterns and realistically assessing doses. Function D stimulating players via radiation levels for decontamination is somewhat different from the requirement in Function C in that a contaminated vehicle or person even though removed from the area on the ground in which there is radiological contamination, will still be subject to the effects of the radiation due to contamination. Also there should be a capability of reducing the radiation level as effective decontamination is conducted, and assessing additional dose levels when the persons conducting decontamination use improper procedures to protect themselves. Function E consists of assessing and assigning casualties due to initial effects of a nuclear burst and function F is the associated indication of such casualties. Functions G and H are the assessment and assigning of casualties to delayed effects, primarily radiation, and indicating these effects to players. Function L consists of recording levels, doses, and casualties. This is somewhat different from the recording requirements in the conventional system in that radiation doses are cumulative and casualties will occur when certain levels of radiation dose have been reached and an appropriate delay has occurred in which the dose levels take effect.

Figure 2-12 recapitulates the training functions which are provided in part by the current NTC and which can be accomplished with minor modifications to the NTC.

FUNCTION	IMPLEMENTATION
A. INFORMATION FROM HIGHER HEADQUARTERS	USE EXISTING ROLE PLAYERS
PREPARE FOR NUCLEAR ATTACK	
CONDUCT RADIOLOGICAL RECONN	
PREPARE FOR BLUEFOR NUC STRK	
I. OBSERVE PREPARATION AND ACTIONS	USE EXISTING FIELD CONTROLLERS
COMMAND AND STAFF	
SPECIALISTS	
TROOPS	
J. EVALUATE ACTIONS	USE EXISTING CONTROLLERS WITH ADDITIONAL STATISTICS IN SOFTWARE
K. RECORD INITIAL CASUALTIES	AUGMENT EXISTING SOFTWARE
M. RECORD COMMAND, STAFF, SPECIALIST TROOP ACTIONS	AUGMENT EXISTING SOFTWARE
N. RECALL FOR AAR	USE AUGMENTED CURRENT AAR SYSTEM

Figure 2-12. Training functions provided in part by current NTC

Figure 2-13 recapitulates the eight functions which are new and which might be provided to augment the current NTC training system.

B. STIMULATE PLAYERS VIA NUCLEAR BURST

C. STIMULATE PLAYERS VIA INDUCED RADIATION/FALLOUT

D. STIMULATE PLAYERS VIA CONTAMINATION SIMULATION

E. ASSESS, ASSIGN INITIAL CASUALTIES

F. INDICATE INITIAL CASUALTIES

G. ASSESS, ASSIGN DELAYED CASUALTIES

H. INDICATE DELAYED CASUALTIES

L. RECORD/DISPLAY RADIATION LEVELS, DOSES AND DELAYED CASUALTIES

Figure 2-13. New training functions required for NTC NW

2-5 SELECTION AND EVALUATION OF DESIGN ALTERNATIVES

2-5.1 Initial Assumptions

Initial assumptions and constraints were identified to be applied in the selection of design alternatives. The first constraint is that only unclassified inputs can be used on the NTC computer. The necessity to appropriately protect classified information in the NTC computer system would be an unacceptable constraint on current operations.

The second assumption or constraint is the control of nuclear fires in the play of the exercise will be at corps and elements above corps. This eliminates the need for certain flexibility in the nuclear warfare training system to accomodate initiatives at the player level which cannot be preplanned.

It was assumed that tree blow down due to nuclear effects and craters of the magnitude attainable with nuclear weapons would not be played in the NTC exercise. The problems with including these effects is indicating them realistically without intrusion of artificial markers and so forth. In alternatives which rely on computer utilization for effects, the inclusion of tree blow down and cratering in calculations requires additional storing of initial effects, but beyond this, does not present a significant problem. The problem in including these two phenomena is essentially in providing a realistic indication of their occurrence.

It was assumed that radiation dose is the only cumulative phenomena. Other effects such as blast and thermal will either produce a kill or produce damage which is so slight that it need not be recorded for future addition of corresponding effects which when aggregated may lead to casualties.

2-5.2 Criteria

The criteria used in the selection and evaluation of design alternatives were: training effectiveness, useability, cost, and risk. Specific training effectiveness characteristics were identified for each function rather than attempt to select training effectiveness characteristics that would apply to all functions. Useability of the alternatives for each function included safety, environmental impact, and flexibility. Flexibility included using design alternatives a number of ways as may be required in different training situations or scenarios as well as using the design for possible future additions, such as chemical warfare. Cost criteria included developmental costs, procurement costs to actually buy the components of the system, as well as initial training, and operating costs. Operating costs include manpower and maintenance.

Developmental risk is also included in evaluating alternatives. More specific criteria are discussed in the evaluation of design alternatives for each function.

2-5.3 Methodology

The methodology in selecting and evaluating design alternatives consisted of three basic steps:

- Identify desired characteristics
- Postulate alternative designs to satisfy the characteristics
- Compare and evaluate the alternative designs

Desired characteristics of the system were determined from requirements analysis, engineering analysis, discussion with knowlegeable people, and literature search. Once the alternatives were identified, alternative systems which could satisfy these alternatives were postulated. The basis for this postulation was engineering judgement and research of current and possible future systems. In some cases the evaluation of design alternatives was carried out in two sub-steps. The first sub-step was to eliminate obviously unsuitable designs by preliminary analysis. This was an efficient way of eliminating designs that did not need to be further analyzed so that the main effort could be spent on analyzing more viable designs. This sub-step was not used in all cases but only when appropriate. Following elimination of obviously unacceptable design alternatives, the remaining alternatives in some cases were defined in greater detail in a second sub-step. Then remaining designs were evaluated on the basis of how well they satisfied desired characteristics. The three step approach, in some cases with an additional two sub-steps, is used in each of the following selections and evaluations of design criteria.

2-5.4 Design Alternatives for Stimulating Players via a Nuclear Burst Cue

<u>2-5.4.1 Desired Characteristics</u> are as follows:

- Near simultaneous notification of players is essential for realism. In a true nuclear burst all players would know at the same time that a nuclear burst had occurred.

- The nuclear burst cue should be visible to appropriate players under combat like conditions in the course of the maneuvers. This includes simulated battle distractions, inclement weather at night as well as day.

- A nuclear burst cue should be audible under similar conditions as above.

- A nuclear burst cue should be distinctive, that is it should not be confused with any other occurrence in the maneuver.

- The nuclear burst cue should be an attention attractor. In fact it should be arresting so that it would be impossible not to know that the nuclear burst has occurred.

- The nuclear burst cue should have an all weather capability including any weather condition that might be encountered at Fort Irwin such as wind, rain, possibly snow, during either night or day. This requires a capability of not only being observed by the players, but a capability of being emplaced and operated under these conditions.

- A nuclear burst cue should be capable of being operated in all terrain. This will facilitate moving the system to an area where it is to be employed without using expensive transportation procedures and equipment.

- The nuclear burst cue should be simple to use so that it does not require especially skilled technicians and a great deal of time to set it up.

- There should be no requirement for intrusive controller actions in which the controller is interjected unrealistically into the maneuver action to inform the players what is happening.

- The nuclear burst cue should provide for training measurements. This includes measuring the top and the bottom of the nuclear cloud as well as measuring the time from which a light pulse occurs until the nuclear burst cue is heard. This flash to bang measurment is used to determine the distance to the nuclear detonation and when combined with the cloud measurement, can provide an estimate of the yield.

- The nuclear burst cue should be safe to use both from the trainee standpoint and also the installer and operators.

- The nuclear burst cue should have no adverse environmental impact. This includes setting of fires. It might also include adverse effects on the Goldstone station near the Fort Irwin reservation.

• Finally, the nuclear burst should be low cost. It should have a low R & D cost which ideally means it is an off-the-shelf item. It should have a low procurement cost. That is, individual burst cues should be low cost as well as the initial training to put that particular nuclear burst cue into operation. Costs also include operating costs such as manpower to install the system, manpower to monitor its effects and for some alternatives, manpower to actually do the stimulation.

2-5.4.2 Initial Screening Three generic classes of burst cues were initially considered in as shown in Figure 2-14.

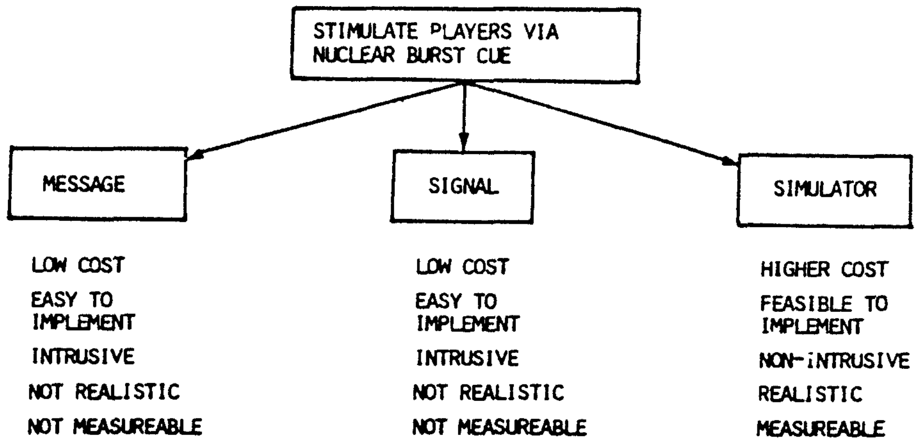


Figure 2-14. Classes of burst cues for initial screening

These three classes were messages, signals, and simulators. A message, for example, is telling each crew the nuclear burst has occurred. A signal is using some device which does not look like a nuclear burst but has been predesignated to be one, for example, a red star parachute cluster. The third approach is to use a simulator which has many of the characteristics of a nuclear detonation. As shown in Figure 2-14 the message is low cost and easy to implement but intrusive in that controllers would have to go to each vehicle or individual to tell him what happened. It was not realistic and there was no way of measuring the nuclear cloud. The signal approach is also low cost, easy to implement but would require telling everybody in advance what the signal was to be. It is intrusive in that it injects an element of artificiality to the battlefield and it is not realistic and not measureable. The simulator is higher cost, feasible to implement and non-intrusive. It is realistic and it provides the needed measurements albeit that these measurements are not those which would give the real nuclear weapon characteristics, however, the measurements could be intercepted by controllers in the course of being reported and realistic cloud sizes and time between visual and audio sensings could be inserted so that

the analyst used realistic numbers. It was decided that the message and the signal approach should be initially eliminated and not further considered because they are intrusive, not realistic and not measureable.

Desired characteristics for a nuclear burst simulator (as opposed to a nuclear burst cue) are identified in greater detail as shown in Figure 2-15.

- VISIBILITY
  - RANGE 5-15 KM
  - DISTINCTIVE SIGNATURE (BRIGHT FLASH, BRILLIANT FIREBALL, MUSHROOM CLOUD)
  - DAY-NIGHT OBSERVABLE UNDER COMBAT CONDITIONS
  - NOTICEABLE BY VEHICLE CREWS
- AUDIBILITY
  - RANGE 5 KM
  - INTENSE SHARP CRACK AND RUMBLE
  - DISTINGUISHABLE FROM "BATTLE" SOUNDS
  - NOTICEABLE BY VEHICLE CREWS
  - DISTINCTIVE SOUND
- MEASUREMENTS
  - TIME BETWEEN FLASH AND SOUND
  - SCALED YIELD (HEIGHT AND DIAMETER OF MUSHROOM CLOUD)

Figure 2-15. Desired characteristics of burst simulator based on second level screening

- Visibility

  The nuclear burst simulator should have a range from which it can be seen of 5-15 kilometers. The distance across to the maneuver area from side to side is on the order of 10 kilometers or more. The simulator should have a distinctive signature emulating a nuclear burst, that is, a bright flash, a brilliant fire ball and a mushroom cloud. The mushroom cloud is not present in a deeply buried atomic demolition burst and may not be present in very high air bursts. However, the mushroom cloud is a necessary option. The nuclear burst simulator should be available in both day and night. At night the flash becomes more important and in daylight the mushroom cloud is more important.

Ideally, a nuclear burst simulator should be noticeable by vehicle crews; this may be very hard to obtain.

- Audibility

  The burst simulator should be heard over a distance of 5 kilometers or more. The noise should consist of a sharp crack followed by a long rumble. The noise should be distinguishable from other battle-like sounds in a maneuver area such as the firing of tank main armament and the detonation of artillery projectiles. The sound should also be noticeable by vehicle crews; it is recognized that this may be difficult to achieve. The sound should be distinctive so that it is not confused with anything else.

- Measurements

  As stated earlier the measurements required are the time between the flash and sound to provide an estimate of distance from the observer at which the nuclear burst occurred. In addition, the height and diameter of the mushroom cloud should be measured by designated technicians. These measurements, as described earlier, can be intercepted by control personnel and appropriately changed so that at the staff section charged with calculating the distance to the nuclear detonation and estimating its size, results will be realistic.

2-5.4.3 Nuclear Burst Simulator Candidates These candidates are illustrated in Figure 2-16.

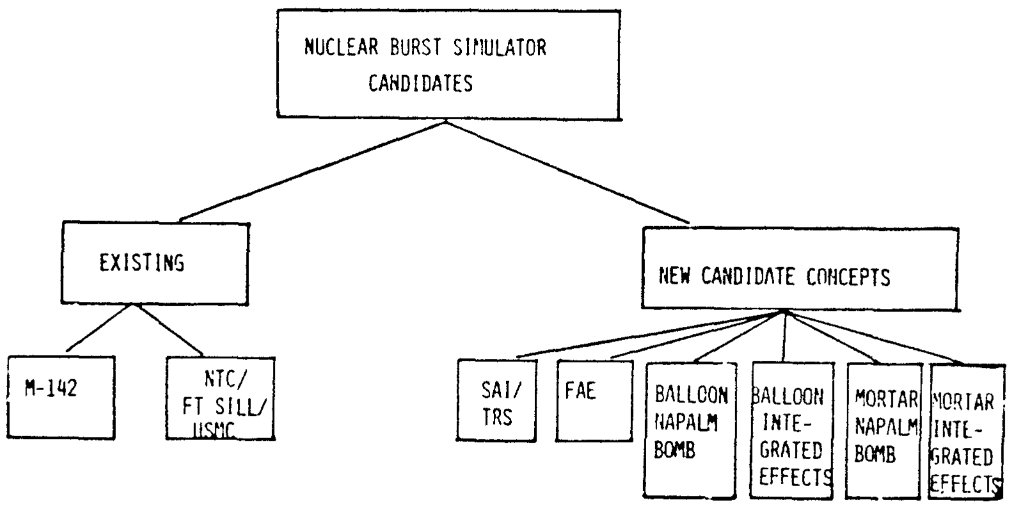


Figure 2-16. Nuclear burst simulator candidates

There are two types of existing candidates plus a number of new candidate concepts. The two types of existing candidates consists of the M-142 simulator and also a variety of simulators which are manufactured locally. This latter group essentially uses the same approach for all designs. This includes the simulators being built at NTC, those built at Fort Sill and those used by the Marine Corps.

The M-142 simulator produces a bright flash, a loud report, and a small mushroom shaped cloud with a very rapid rise. The effects of this simulation are that it generally performed unfavorably in practice. Troops using it did not recognize it as a nuclear burst. Troops in vehicles did not sense that anything had happened. It was ineffective because it was masked in hilly terrain. It was not distinctive under combat like conditions in maneuvers. The overall result is that users are making substitute devices. The M-142 simulator is shown in Figure 2-17.

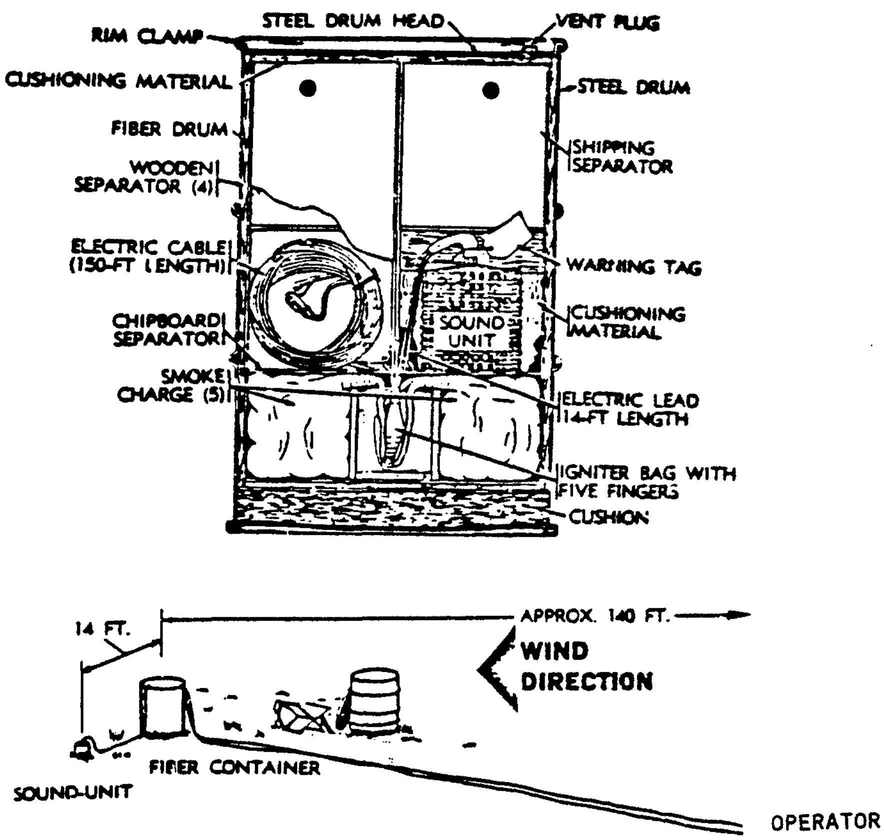


Figure 2-17. M-142 simulator

As shown in the figure, the entire simulator comes packaged in a 55 gallon drum. The actual active ingredients are relatively small. There is a sound unit, ignitor bags and smoke charges. A 150 foot long cable is provided to operate the system. The whole device is taken out of the steel drum, the fiber container is set up, the sound unit is positioned to the side approximately 14 feet. Then the operator lays 150 feet of cable so that the device is down wind from him. The cable is used by a control person to detonate the device.

Figure 2-18 shows the composition of various alternative burst simulators.

CURRENT NTC SIMULATOR

55 GALLON DRUM OF JELLIED GASOLINE
4 QUARTER LB. C-4 CHARGES
200 FEET DETONATING CORD
6 TO 8 LBS TNT LIFTING CHARGE
INCENDIARY BURSTER AND IGNITOR
PHOTOFLASH ELEMENT (2×10^8 C.P.) MAY BE ADDED

FT. SILL SIMULATOR

55 GALLON DRUM OF JP-4 AND GASOLINE
2 LBS. OF TNT
THERMITE GRENADES
WRAPPED WITH DETONATING CORD
EMPLACED IN EARTHWORKS
SIMULTANEOUS DETONATION

U.S.M.C. SIMULATOR

55 GALLON DRUM OF NAPALM
1/4 LB. TNT BLOCKS
PHOSPHORUS GRENADES
CONCUSSION GRENADES
2 STAGE DETONATION - VAPORIZATION FOLLOWED BY IGNITION

Figure 2-18. Alternative burst simulators

They all use 55 gallons of napalm, or jellied gasoline. They all use a variety of charges to rupture the 55 gallon drum. Most do not use primacord (detonating cord) however the NTC simulator does. The NTC simulator uses 6-8 pounds of TNT lifting charge to throw the active elements into the air at which time the detonating cord and the composition "C" charges rupture the 55 gallon drum and spread the incendiary material. Following this, the incendiary burster and ignitor combination set off the fireball. There is a possibility of a photoflash element of about 200 million candle power (which is an off-the-shelf item) being added to the current simulator. Other similarly locally designed simulators are in use. They generally produce a large orange-black, greasy fireball and a large, black rapidly rising mushroom cloud. The current NTC simulator is used only at night on the live firing exercise. A mushroom cloud is not important in this application.

Figure 2-19 shows options for emplacement and active devices which were initially considered.

EMPLACEMENT OPTIONS	ACTIVE MATERIAL OPTIONS
• GROUND	• THERMAL RADIATION SIMULATOR
• BALLOON	• FUEL-AIR EXPLOSIVE
• MORTAR	• NAPALM
	• INTEGRATED COMPOSITE SYSTEM

Figure 2-19. New nuclear simulation devices initially considered

Emplacing the simulator on a hill but detonating it from the ground is not expected to meet visibility requirements of being seen all the way across the maneuver area. Another emplacement alternative is to create an air burst using a balloon. However, initial calculations showed that a rather large balloon would be required to lift 300 pounds. The 64 foot long, 10 foot diameter balloon would not meet visibility requirements in that it would be too visible, and after a few exercises the troops would know that the large balloon was located at the point at which there was going to be a nuclear detonation. The third approach projects the simulator into the air. One approach is to use a Navy depth charge projector. Potential active materials included the SAI thermal radiation simulator (TRS), which is basically a zero thrust rocket engine providing a brilliant flame. The thermal radiation simulator does not provide visibility, audibility and measurement requirements. Fuel Air Explosive (FAE) was considered, but the problem of cleaning up FAE if it had not detonated, could greatly interfere with the maneuver in addition to being a significant safety hazard. Napalm, scattered by a bursting charge followed by ignition was considered, however, it was estimated that this would not meet the visibility and measurement requirments. The integrated use of active materials consists of argon gas to produce an initial light pulse, a pyrotechnic cartridge for a second light pulse, napalm for the sustained fireball, smoke and sequenced sound charges to provide the proper relationship between seeing the blast and hearing it. This analysis led to the SAI Integrated Nuclear Burst Simulator. This is shown in Figure 2-20.

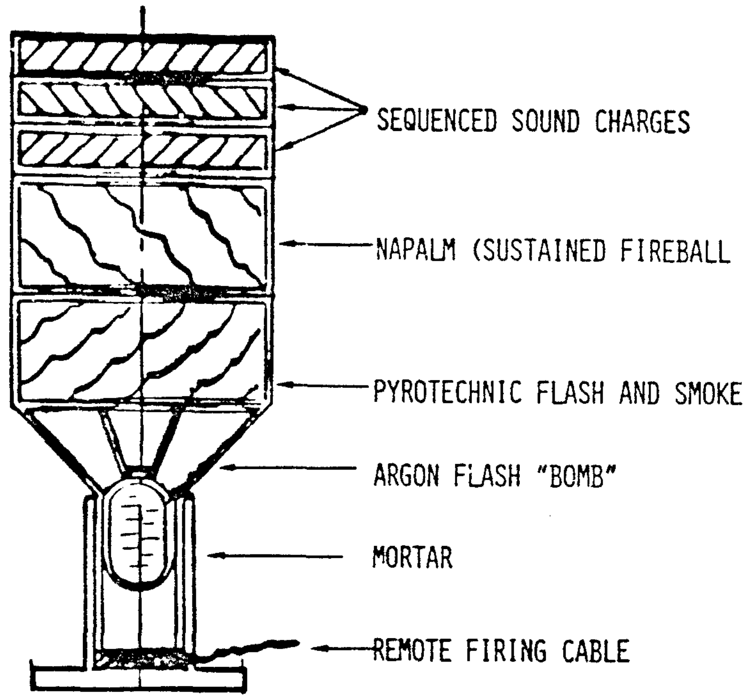


Figure 2-20. Schematic SAI integrated burst simulator

The simulator consists of sequenced sound charges, napalm to produce a sustained fireball, provision for a brilliant, pyrotechnic flash and smoke, an argon flash bulb and a depth charge unit as a launcher (Figure 2-21).

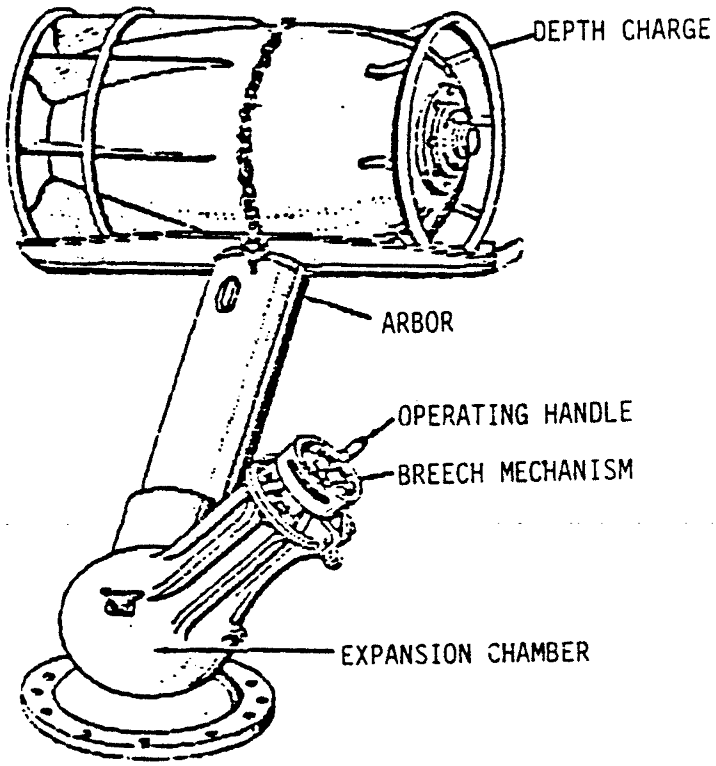


Figure 2-21. Naval depth charge launcher

The launcher is activated by a remote firing cable. Figure 2-22 shows the evaluation of the three remaining candidates, the M-142, the locally produced (such as that used at NTC) and a new mortar launched simulator, in which case the mortar may be a war surplus depth charge launcher.

	M142	NTC/ FT. SILL/ USMC	NEW MORTAR LAUNCHED
TRAINING EFFECTIVENESS			
CLOUD	2	2	4
FLASH		3	4
AUDIBLE		2	4
DISTINCT	2	3	4
ARRESTING	0	3	3
RANGE	0	2	3
AIR BURST			3
USEABILITY			
SAFETY	3	3	4
WIND LIMIT	0	2	4
SET UP	3	3	3
COST			
R&D	4	4	2
UNIT COST	4	4	3
SET-UP COST	3	2	3
DEVELOPMENT RISK	4	4	3
TOTALS	25	37	43

LEGEND: 4 EXCELLENT; 3 GOOD; 2 FAIR; 0 POOR

Figure 2-22. Evaluation of candidates for stimulating players via a nuclear environment

2-5.4.4 Evaluation of Alternatives The scale for evaluating was excellent, good, fair, poor. In addition, in order to show the overall relationship, numerical ratings of 4, 3, 2, and 0 respectively were assigned to adjetival ratings. These ratings were used for all design alternatives. The

production of a cloud was poor for the M-142 and the locally made simulators as compared to an excellent cloud for the new mortar launched approach. There was no effective flash from the M-142. There was a fair flash in the NTC locally made simulator especially at night, however the new integrated approach appeared to have a more realistic flash. The same can be said for audibility. The M-142 was only fair in distinctiveness because it could not be seen in all cases and could not be differentiated from other occurrences. The locally made simulators are good in this respect since they contain a large amount of active ingredients. However the specially designed integrated mortar launched simulator would even be more distinct. The M-142 is not arresting, having a range of about 1 kilometer and has no air burst. The locally manufactured simulator is arresting, as is the new mortar launched proposed simulator. The range of the locally manufactured simulator would be somewhat less than the mortar launched simulator because the former does not employ an air burst configuration. Respective ranges are 2 and 5 kilometers. The new mortar launched simulator is the only one with an air burst. It was felt that in the manufacturing process, better safety can be obtained than in the locally made system. The black powder used for the M-142 make it appear that this simulator would not be as safe as one that might be based on a new design.

The M-142 is good for winds up to about 5 mph, the locally made simulators up to about 20. Because of its air burst, the mortar launch would be useable somewhat higher because it can be observed from the high altitudes in which it was detonated before the cloud is dissipated. Set up times for all systems were judged to be good although the locally manufactured ones will probably take the longest time to set up. The R & D cost of the existing systems is of course excellent. The cost of proposed nuclear burst simulator was rated as fair. The unit costs are about $1400 for the M-142, roughly $500 for the NTC locally produced and $3000 to 5,000 for the mortar launch integrated simulator. The latter probably may be produced in larger quantities for less than this amount. The set up cost including the manufacturing and the assembly of the locally produced NTC simulator is higher than either of the setup costs for the M-142 or the mortar launched. There is essentially no development risk for the M-142 or the locally produced simulators. There is a slight development risk in the new mortar launched. As can be seen at the totals at the bottom, the best approach (by a considerable margin) is the mortar launched integrated effects simulator. The locally produced simulators are considerably behind that, and far behind both is the M-142.

2-5.5 Design Alternatives for Stimulating Players Via Induced/Fallout Radiation

2-5.5.1 Desired Characteristics are as follows:

- Realistic readings on radiac meters are required so that players using the normal monitoring techniques will be aware that a simulated radiation pattern exists. Readings should vary realistically with time and with location. There should be a provision for meters within sheltered locations, such as within armored personnel carriers, to read less than meters on the outside in more exposed positions.

- Realistic readings on dosimeters should reflect the history of the location of the wearer of the dosimeter. As in the case of readings on the radiac meters, the total accumulated dose for personnel in sheltered areas should be less than personnel who are exposed. Readings should also reflect when the dosimeter was last zeroed, so that the doses read are not the cumulative dose for the individual, but rather are the doses on meters since they were last zeroed.

- Radiation rate patterns should be a function of time and location. In the case of fallout, the rate should rise and then fall. The variation in location should generally follow the predictable fallout pattern with variations to add realism. These variations include not only a distortion of pattern but hot spots within the pattern.

- Doses should be a function of time and location history so that the doses truly reflect the exposure which has been experienced.

- Total dose for players should be maintained for casualty assessment and after action reviews. One teaching point in the nuclear warfare training is that players may be exposed to lethal doses during the short duration of an exercise and never have the fact that they have been exposed to this level visible except by means of maintaining dose records. One approach might be to have initial doses assigned at the beginning of the exercise to simulate the fact that the exercise is occurring at some point weil into a prolonged war. Total dose should be available for teaching and critiquing in after action reviews.

- Radiation patterns should be available for controller use and for after action reviews. It will be helpful if radiation patterns can be presented on graphic displays for use in determining effects and critiquing the actions of players.

- Simulation of induced/fallout radiation should be non-intrusive so that it does not destroy the realism of the exercise nor give players false training by presenting cues that would normally not be present.

- The simulation of induced/fallout radiation must be safe. This includes actual safety and safety as may be perceived, which could lead to long and expensive testing to make sure a system was useable.

- There should be no adverse environmental impact in the design selected. This includes contaminating areas which may have to be cleaned up before additional exercises can be conducted.

- The system selected should have low costs to include R & D cost, procurement costs, and operating costs.

2-5.5.2 Design Alternatives Design alternatives are shown in Figure 2-23.

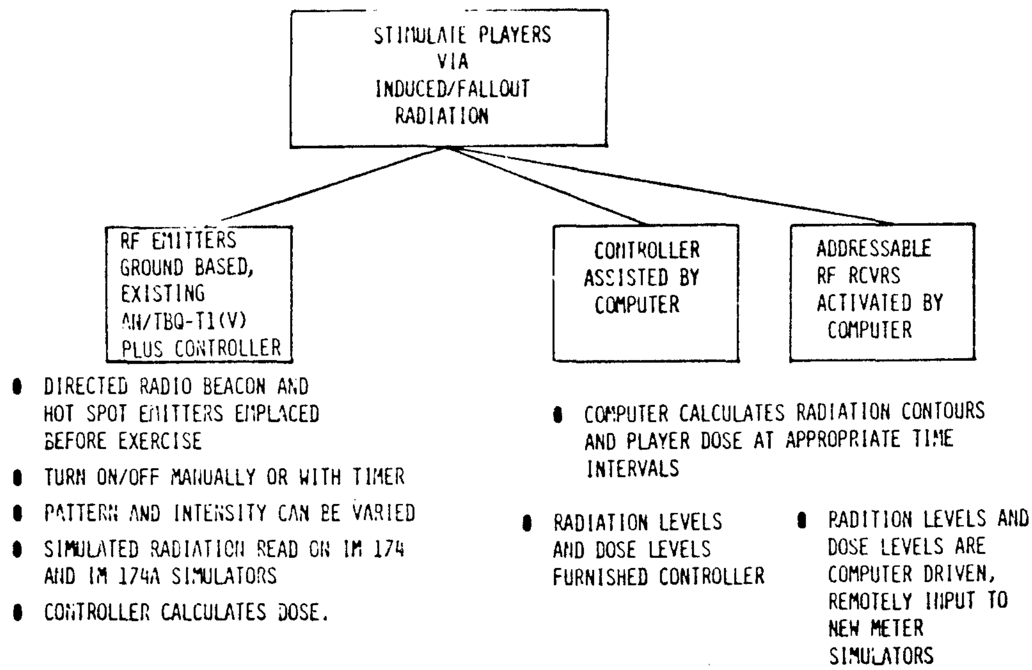


Figure 2-23. Design alternatives for stimulating players via induced/fallout radiation

Initially the establishment of radiation patterns by spreading an emitting material was considered. However, this approach was eliminated in an initial screening because of difficulties in meeting safety requirements and in contaminating the area, requiring time consuming and expensive cleanup between exercises.

Currently at NTC, the AN/TBQ-T1(V) radiation training system is used. In this system there is a directed radio frequency beacon which produces a pattern of radiation approximating that of the nuclear radiation. There are simulated IM174 and IM174A radiac meters which read the RF radiation and show a simulated nuclear radiation rate. In addition to the main emitter there are a number of hot spots, consisting of small RF radiators. These are implaced before the exercise, along with the radio beacon. The emitters can be turned on and off manually or with a timer. The pattern and the intensity of the RF radiation can be varied with time. In this system, as currently used, the field controller estimates the cumulated dose for each player, based on the controller's knowledge of the radiation pattern. Using this approach, the pattern represented could be programmed in advance into the CIS computer so that there would be some correlation between the actual pattern of the

RF and that which the central controllers use as the correct pattern.

An alternate approach would use a controller assisted by the computer. In this case the computer calculates the radiation rate contours and the player dose at appropriate time intervals. This information is stored and furnished to the controller who in turn gives the radiation levels and the dose levels to the players. The controller may furnish the radiation levels or dose levels simply by telling players what the readings would be on instrumentation or the controller may actually set the instruments before players read them. This approach uses the current NTC capabilities for tracking players, combined with the dose rate at every point on the ground, so that the integral of rate and time provides a realistic estimate of the actual dose received. Attenuation factors would be programmed into the computations so that the controller can furnish information on the vulnerability posture (e.g. on foot, in a truck, or buttoned up in an armored personnel carrier or tank) which can be included in the dose calculations.

A third approach is also computer based. In this case radiation contours and dose levels are again determined by the computer but the information is sent to addressable radio frequency receivers which simulate radiac meters. Each RF receiver would be discretely addressable using a digital code and the particular receiver assigned to a unit can be tracked by the location of the unit. Comparison of the location of the RF receiver and the radiation pattern in the computer will provide the radiation rate for that meter. The controller in the field can observe whether the unit or the person taking the radiation readings is sheltered or is exposed and provide this information to the central computer which can include the attenuation factor when it furnishes the radiation rate reading to the addressable RF receiver. A similar approach could be used for simulated dosimeters. However, it is questionable that the dosimeter simulator could be packaged as small as the current actual dosimeter, which is about the size of a large fountain pen. An alternative would be to provide a device to set the dosimeter, so that an added process could be incorporated in which the dosimeter simulator was placed in a box-like RF receiver that would set the total dose on the instrument.

2-5.5.3 Evaluation of Alternatives Evaluation of alternatives is shown in Figure 2-24.

	RF EMITTERS PLUS CONTROLLER	CONTROLLER ASSISTED BY COMPUTER	ADDRESSIBLE RF RCVRS
REALISTIC READINGS ON RADIAC METERS	3	3	4
REALISTIC READINGS ON DOSIMETERS	2	3	4
RADIATION RATE PATTERNS	3	4	4
PLAYER DOSES	2	4	4
TOTAL DOSE MAINTAINED	2	4	4
RADIATION PATTERN AVAILABLE FOR AAR	3	4	4
NON-INTRUSIVE	3	2	4
SAFE	4	4	4
NO ADVERSE ENVIRONMENTAL IMPACT	4	4	4
R&D COST	4	3	2
PROCUREMENT COST	4	3	2
OPERATING COST	2	3	3
TOTAL SCORE	36	41	43

LEGEND	4	3	2	0
	EXCELLENT	GOOD	FAIR	POOR

Figure 2-24. Evaluation of alternatives for stimulating players via induce/fallout radiation

The alternative systems are evaluated on the basis of the desired characteristics. All systems have realistic readings on the radiac meters although the addressable RF receiver is slightly better since more realistic patterns can be obtained. The computer assisted approaches are better for providing total doses and the addressable receivers are the best of all. A difficult job of keeping track of total dose accumulated is considerably facilitated by the computer. For the same reason the computer approaches were judged best in terms of radiation rate patterns and player doses. The computer assisted approaches also do a better job in maintaining total doses and in providing radiation patterns for after action reviews, since the information is already available on the computer. The second system which relies heavily on the controller actions was more intrusive than both first system (use of RF emitters) and the third system employing addressable RF receivers. All systems were safe and had no adverse environmental impact. R & D cost of the existing system is

the lowest as is the procurement cost. The R & D cost of new receivers, and the procurement cost, would be higher since this hardware has not been built. However, the hardware would be relatively simple and is well within the state of the art. Furthermore, it is compatible with the existing A stations and B stations now in use in the National Training Center. The second two systems would probably produce a savings in operating costs since the setup and maintenance of the current AN/TBQ system could be reduced. The overall rating shows that the best system would be computer based using addressable RF receivers followed closely by the computer system to assist the field controller. The present RF system suffers from the problem of a large task for field controllers in keeping track of doses and in maintaining the system which is understood to be somewhat fragile. The controller workload in the first approach could be partially reduced by combining the use of RF emitters with computer assistance as was done in the second design alternative.

2-5.6 Design Alternatives for Stimulating Players via Contamination Simulation.

2-5.6.1 Desired Characteristics are as follows:

- Detectability of contamination should be realistic. Detection will be primarily by the use of radiac meters. Even if the contaminated vehicle or person leaves the area of radiation, the contamination should still be apparent until decontamination has taken place.

- The build up of contamination should be realistic occurring in the approximate same manner as fallout.

- There should be measureable evidence of successful decontamination. This will be again primarily by means of radiac meters.

- There should be penalties for wrong procedures which expose decontamination personnel to contamination. This could be in the form of increased doses and/or showing contamination of these people.

- The design for contamination simulation should be non- intrusive so that the actions and observations are as they would actually occur without interrupting the exercise or providing unrealistic cues as to the presence of contamination.

- The alternative selected should be safe.
- There should be no adverse environmental impact.
- The system should have low R & D cost, procurement costs, and operating costs.

2-5.6.2 Design Alternatives. As shown in Figure 2-25, four design alternatives were considered.

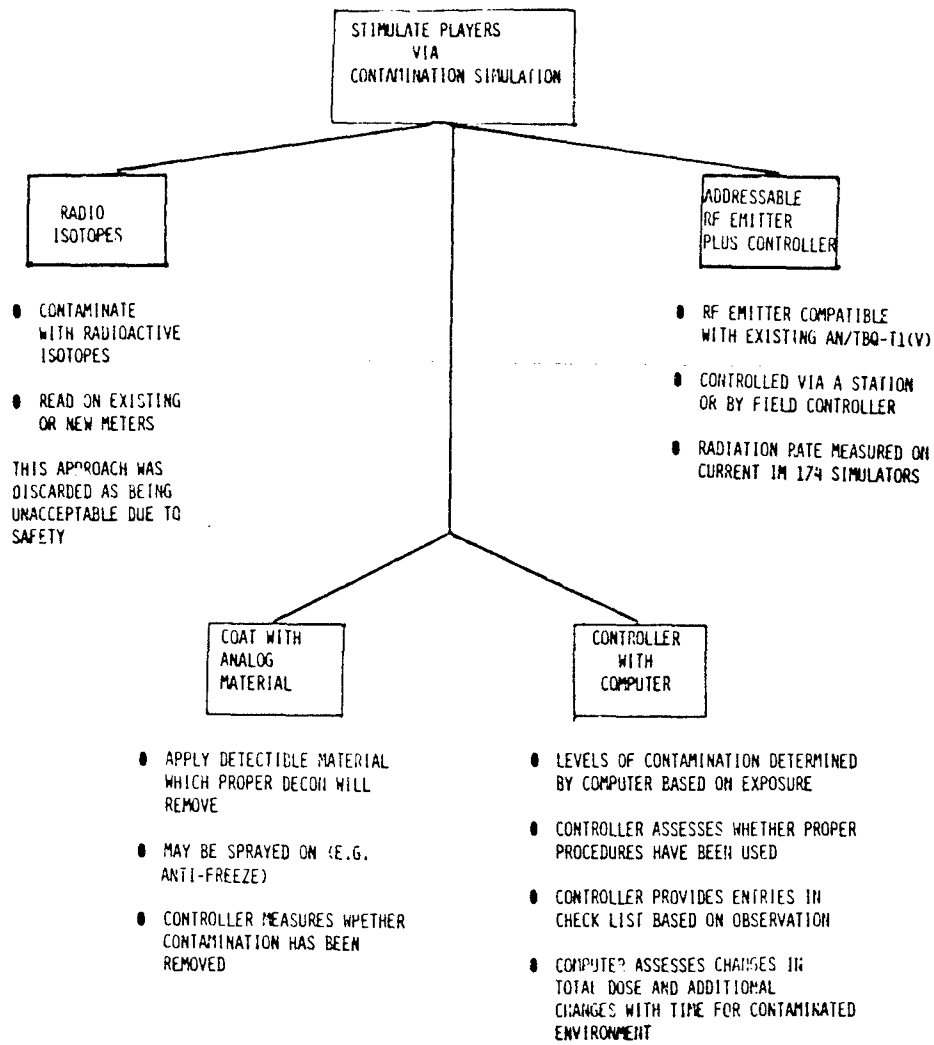


Figure 2-25. Design alternatives for stimulating players via contamination simulation

The first was the use of radio isotopes to contaminate an area in such a manner that contamination could be read on existing meters or new meters. This approach was discarded in initial screening as being unacceptable because it would be too difficult to demonstrate that the system was safe.

The second approach consisted of applying an analog material which can be detected on a meter simulating a radiacmeter. Polyethelyne Glycol (PEG) has been used in this manner for simulating chemical contamination and could be used to simulate nuclear contamination. The third approach is for the controller to designate contamination with the aid of computer input. In this approach levels of contamination would be calculated and stored by the computer for each affected player unit (e.g. APC crew) and provided to the controller. A fourth approach consists of an addressible RF emitter, which can be turned on remotely. The RF emitter would be mounted on each vehicle, and its output would be compatible with the AN/TBQ-T1(V) simulated meters which are now being used.

2-5.6.3 Evaluation of Design Alternatives As shown in Figure 2-26, the addressable RF emitter provides the most realistic detectability, the most realistic buildup, and the best measureable evidence.

	ANALOG MATERIAL	CONTROLLER WITH COMPUTER	ADDRESSABLE RF EMITTER PLUS CONTROLLER
REALISTIC DETECTABILITY	2	3	4
REALISTIC BUILD UP	0	3	4
MEASUREABLE EVIDENCE	3	0	4
ASSESSABLE PENALTIES	2	3	3
NON-INTRUSIVE	0	3	4
SAFE	3	4	4
NO ADVERSE ENVIRONMENTAL IMPACT	4	4	4
R & D COST	4	3	2
PROCUREMENT COST	4	3	2
OPERATING COST	3	4	3
TOTAL SCORE	25	30	34

LEGEND: 4 EXCELLENT; 3 GOOD; 2 FAIR; 0 POOR

NOTE: APPROACHES ARE NOT MUTUALLY EXCLUSIVE AND COULD BE COMBINED

Figure 2-26. Evaluation of alternatives for stimulating via contamination simulation

The controller, using inputs from the computer also provides realistic detectability and buildup, however there is no measureable evidence of decontamination. Analog material shows a less realistic detectability because the analog material does not necessarily duplicate the effects of radiological contamination. The buildup is quite unrealistic using an analog material sprayed on or deposited in some other manner, however, it does provide measureable evidence of contamination. The analog material probably does not provide a significant penalty for improper decontamination. Depending on the actions of the controller, the last two approaches could provide assessible penalties. Analog material is the most intrusive due to the obvious application of such material. The last two approaches are relatively non-intrusive. All approaches are safe except that the analog material may have some small

safety implications. None of the alternatives have adverse environmental impact. Using an existing analog material there is little R & D or procurement costs, providing a readily measured analog material is used, and a sophisticated meter simulating the IM-174 or IM-174A is not required providing an available detector is used. In using the controller aided by the computer there is an R & D procurement cost for additional software. The addressable RF emitter plus controller appears to be well within the state of the art so that R & D cost and procurement cost would probably be reasonable. The analog material probably has the highest operating costs since the material must be constantly replaced. The controller aided by the computer would have essentially no additional operating costs except for software maintenance. The addressable RF emitter would have additional operating costs due to maintenance of the emitters. The addressable RF emitter is not consistent with computer based systems in some of the other alternatives but is consistent with the use of the existing AN/TBQ-T1(V). It should be noted that approaches are not mutually exclusive and could be combined, although combining approaches might be impractical if different meters are required for each type of contamination simulation. The best approach if the AN-TBQ-T1(V) is also used in the NTC NW Training System, is the addressable RF emitter. The second best is the controller aided by the computer; this approach is best if a computer based system is used which does not employ the AN/TBQ-T1(V).

2-5.7 Design Alternatives for Assessing and Assigning Initial Casualties

<u>2-5.7.1 Desired Characteristics.</u> These characteristics are as follows: (Assessing and assigning are defined as described in Section 2-3.)

- Assessment and assignment should be realistic based on the location, including sheltering and defilade, and on the vulnerability posture such as buttoned up, prone, standing, in a foxhole, etc.

- There should be a provision for total kills (as opposed to partial kills or degradation) and also for radiation doses as a minimum.

- The assessment and assignment should be near real time so that all casualties occur nearly simultaneously.

- The results of the casualty assessment and assignment should be available to the controllers and available for after action reviews.

- The system should be flexible so that it can be utilized for a number of scenarios or situations.

- Assessing and assigning should be non-intrusive so that there is no obvious field controller intervention, or actions which serve as an unrealistic cue.

- The alternative should be safe for both the players and the controllers.

- There should be no adverse environmental impact.

- The system should be low cost.

2-5.7.2 Design Alternatives Design alternatives are shown in Figure 2-27.

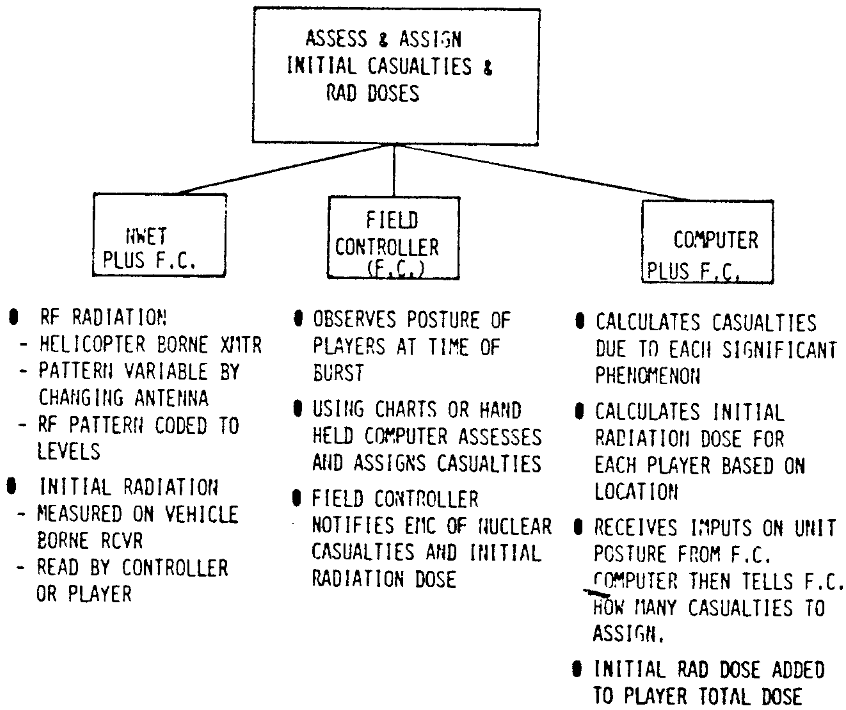


Figure 2-27. Design alternatives for assessing and assigning initial casualties and radiation doses

The first approach is the Nuclear Weapon Employment Trainer (NWET) which has been developed by the Sandia National Laboratories at Livermore. This is a system for communicating the prompt effects of nuclear weapons using information broadcast from an aircraft mounted RF transmitter to ground receivers distributed among troop elements. Receivers indicate the weapon equivalent exposure

level to exercise participants. Weapon effects are stored in the aircraft unit and specific weapons are selected through a self-prompting dialogue. The receivers are self-contained and require no external powers or user interaction. The RF pattern is variable and attained by changing the antenna. The RF pattern is coded to effects levels which may then be read off the vehicle born receiver. The receiver may be read either by the controller or player. In order to determine casualties, each receiver must be read by a field controller.

In the second approach the field controller is furnished advanced information on the location and type of burst and on effects radii, to assist in assessing and assigning casualties. In this method of operation the field controller observes the vulnerability posture and location of the players at the time of the burst. The field controller assess and assigns casualties and notifies exercise maneuver control of nuclear casualties and initial radiation dose. This is stored in the computer for subsequent recall for total dose calculation and for after action reviews.

The third approach consists of the computer aided by the field controller. In this case the computer calculates casualties for each significant phenomena, for example, blast, prompt radiation, and thermal effects. It also calculates the initial radiation dose for each player based on player location and vulnerability posture as input by the field controller. Using the computer, the central controller will then tell the field controller the number of casualties to assign in his area, and the field controller will assign casualties on the basis of observed vulnerability posture. This procedure is analogous to that used in the current National Training Center for the effects of indirect fire. Initial radiation dose would be added by the computer and stored with the total dose for each affected player.

2-5.7.3 <u>Evaluation of Design Alternatives</u> Evaluation is shown in Figure 2-28.

	NWET PLUS FIELD CONTROLLER	FIELD CONTROLLER	COMPUTER PLUS FIELD CONTROLLER
REALISTIC	2	2	3
TOTAL KILLS PROVIDED	4	3	4
RADIATION DOSES PROVIDED	4	2	4
NEAR REAL TIME	2	2	4
AVAILABLE TO CORE CONTROLLERS & AAR	2	2	4
FLEXIBLE	3	2	4
NON-INTRUSIVE	0	3	3
SAFE	2	3	3
NO ADVERSE ENVIRONMENTAL IMPACT	3	4	4
R & D COST	3	4	2
PROCUREMENT COST	2	4	3
OPERATING COST	2	4	4
TOTAL	29	35	42

LEGEND: 4 EXCELLENT; 3 GOOD; 2 FAIR; 0 POOR

Figure 2-28. Evaluation of design alternatives for assessing and asigning initial casualties and radiation doses

The nuclear weapons effects trainer (NWET) plus the use of the controller and the field controller are less realistic than the computer approach, since the computer can better track realistic levels of damage. The field controller is the least effective in assessing the total kills because of the work load in keeping track of what has happened. NWET and the computer approach are most effective in providing initial radiation doses. The recorders in the NWET must be read before initial casualties can be assessed and assigned. The field controller must perform certain calculations which may be time consuming. The computer approach is closest to real time and also provides infcrmation directly to control and for after action reviews. The computer approach is also the most flexible. The unaided field controller is probably least flexible since to do the job properly he would have to have a great deal of advance information on the areas of nuclear effects. The NWET is highly intrusive in that the presence of the helicopter is an undesireable cue that

something out of the ordinary is happening; in a short time troops will associate this with the occurrence of a nuclear burst. Use of the helicopter makes this system somewhat less safe than the other two and may provide a small adverse environmental impact on the training environment. The NWET is in development so that its overall R & D cost may be somewhat higher than the computer plus field controller which only requires development of additional software. Procurement costs of the NWET would be highest because of the large amount of special hardware. The cost of procurring an essentially dedicated helicopter is also added to NWET. Because of the helicopter, the operating cost of NWET is considerably higher than the other systems. Although the NWET is a potentially useful approach for large field exercises it does not take advantage of other instrumentation in the National Training Center and is unacceptably intrusive and costly. It scored lowest of the three designs. The computer plus the field controller scored highest.

2-5.8 Design Alternatives for Indicating Initial Casualties

<u>2-5.8.1 Desired Characteristics</u> are as follows:

- Indications should be essentially in real time so that there is not a large delay between the time that the casualty producing phenomena occurs and the time in which the casualties are indicated to the players.

- The system should be non-intrusive, so that there is no obvious controller action which may provide an unrealistic cue as to what elements have become casualties.

- Indication of casualties should be realistic and not provide more or less information than would be realistically expected. For example, if the only indication that a tank is knocked out is the fact that it is not moving, this should be the only indication provided to players.

- The system should indicate total kills as a minimum. Indication of partial damage or degradation would be nice to have but may not significantly contribute to training.

- It may be desireable to indicate to appropriate players that they are imminent casualties. For example, players who have received a large radiation dose and are imminent and certain casualties may take some particular action (such as driving their tank to a designated area where a replacement crew can be provided.)

- The system should be safe.
- There should be no adverse environmental impact.
- The system should be low cost in terms of the three factors that have been listed before.

<u>2-5.8.2 Design Alternatives.</u> Design alternatives are shown in Figure 2-29.

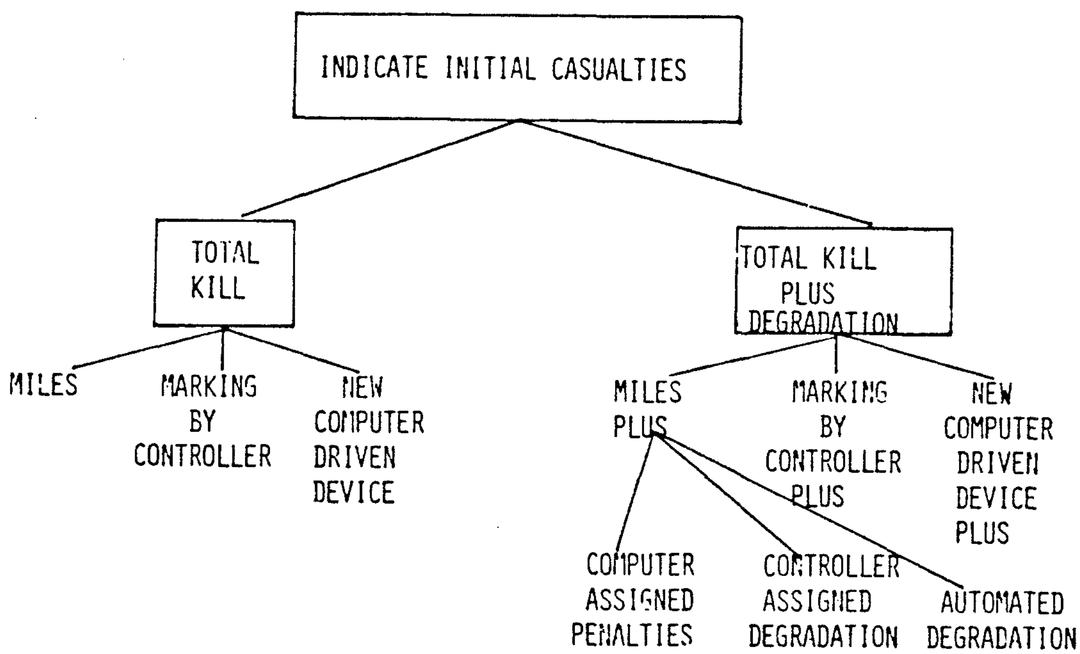


Figure 2-29. Design alternatives for indicating initial casualties

There are two general classes of alternatives. The first shows total kills only and the second shows total or complete kills plus degradation. The second alternatives include all the first alternatives plus additional capabilities for assigning degradation. It was observed that indicating partial kills or degradation will be quite complicated and it is recommended that (in keeping with the gradual implementation approach to enhancing the nuclear warfare capability) indications of degradation be considered only later as the system matures. There are three approaches shown for indicating total kills. One is to use

the kill light in the MILES system. The other is marking by a controller and a third approach is a new computer driven device similar to MILES but simpler in that it must only record an on-off condition. Figure 2-30 shows considerations affecting the design alternatives.

MILES	MARKING BY CONTROLLER	NEW DEVICE
• PRESENT CAPABILITY FOR ADMINISTRATIVE KILL	• HISTORIC APPROACH USING FLAGS, FLOUR BAGS, ETC.	• LESS FUNCTIONS THAN MILES
• CAN BE ACTIVATED BY CENTRAL CONTROLLER OR FIELD CONTROLLER	• REQUIRES CONTROLLER KNOW DAMAGE AREAS	• MAY USE ALTERNATIVE TO LIGHT
• BLINKING LIGHT PROVIDES DISTINCTIVE SIGNAL	• REQUIRES CONTROLLER GO TO EACH PLAYER	• COMPUTER DRIVEN WITH FIELD CONTROLLER OVERRIDE
• INPUTS FROM FIELD CONTROLLER ON VULNERABILITY POSTURE		• DISTRIBUTED TO LOWER LEVEL THAN MILES

Figure 2-30. Consideration in selecting a design for indicating initial casualties

The MILES system has a present capability for administrative kill that could be utilized by the central controller or the field controller indicating kills due to initial nuclear effects. Whether or not the kill occurred could still be influenced by inputs from the field controller on the vulnerability posture. Marking of casualties by the controller consists of using historic, and in some cases antiquated, approaches such as flags, flour bags which are deposited on the vehicle, on some other similar indication. This approach requires that the controller physically go to each vehicle or player which has become a casualty. A new device would operate in a manner analogous to MILES but have less functions (consisting of only an "on" and "off" condition). It could use an alternative to a blinking light, which may be too distinctive a signal, and it could be directly computer driven with a field controller override. Since it is simpler, it could be distributed to a lower level than MILES.

2-5.8.3 Evaluation of Design Alternatives. As shown in Figure 2-31 both MILES and a new indicating device provide near real time indication, are non- intrusive, are realistic, and indicate total kills.

	MILES	MARKING BY CONTROLLER	NEW DEVICE
NEAR REAL TIME	3	0	4
NON-INTRUSIVE	4	2	4
REALISTIC	3	0	4
INICATES TOTAL KILLS	4	4	4
IMMINENT CASUALTIES NOTIFIED	0	3	3
SAFE	4	3	4
NO ADVERSE ENVIRONMENTAL EFFECTS	4	4	4
R & D COST	4	4	2
PROCUREMENT COST	4	4	2
OPERATING COST	3	2	3
TOTAL SCORE	33	26	34

LEGEND: 4 EXCELLENT; 3 GOOD; 2 FAIR; 0 POOR

Figure 2-31. Evaluation of designs for indicating initial casualties

Marking of casualties by the controller is unacceptable in terms of being not real time and not realistic and is marginally acceptable in being intrusive. MILES does not have a capability for notifying imminent casualties who are radiation kills. All systems are safe. None of the systems have adverse environmental effects. The R&D costs of MILES and the use of the controller are essentially zero. A new device would involve R&D costs although the device would be state of the art and should present no particular problems. The new device would also have the highest procurement costs. Marking by the controller will have the highest operating costs. Use of MILES and the new device had about the same score. Marking by the controller was significantly poorer than either of the other alternatives.

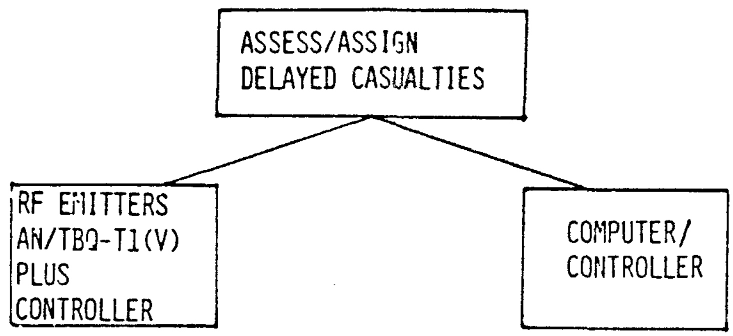
2-5.9 Design Alternatives for Assessing and Assigning Delayed Casualties

2-5.9.1 Desired Characteristics are as follows:

- Assessment and assignment should closely approximate the actual casualties that would be incurred.
- The assessment and assignment should include total incapacitation and total doses as a minimum. Total doses should combine the effects of prompt radiation and delayed radiation.
- The assessment of degradation should be consistent with the ability to indicate and include that degradation in the exercise. There does not seem to be any advantage in calculating and assessing and assigning degradation if it cannot be communicated to the players or included in the exercise.
- Total dose may need to be calculated only for each platoon rather than each individual player, except perhaps in special circumstances where players are assigned particular duties such as decontamination.
- Total dose since dosimeters were last zeroed needs to be available, since this is what would be available to units reading the dosimeters.
- Casualties due to radiation occur(except for very high levels) at some time after the radiation has been received. There needs to be a method of time tagging these casualties so that they can be assessed and assigned at a realistic time after exposure.
- Assessment and assignment of delayed casualties must be available for after action reviews. This includes doses of players who may become casualties much later -- after the exercise is over -- or even doses which will not produce casualties but which may be significant.
- The method of assessing and assigning casualties should be non-intrusive in not requiring the obvious presence of observers to record information.

- The assessment and assigning of casualties should be low cost in terms of R&D procurement and operations.

<u>2-5.9.2 Design Alternatives.</u> (Figure 2-32)



- SIMULATED RAD RATE FROM RF EMITTER
- CONTROLLER ASSIGNS CASUALTIES BASED ON RAD RATE

- COMPUTER SUMS DOSE FOR TIME INCREMENTS BASED ON PLAYER LOCATION
- INPUTS FROM CONTROLLER ON PLAYER POSTURE
- CASUALTIES FLAGGED BY COMPUTER AT APPROPRIATE DOSES/TIMES

Figure 2-32. Design alternatives for assessing and assigning delayed casualties

The first approach consists of using the current RF emitters, AN-TBQ-T1(V); plus a controller. In this approach the controller utilizes the simulation from the RF emitters plus advanced information as to the pattern to give him an approximation of the level to which players are exposed. Using this information he then assigns casualties based on the radiation rate. This places a heavy work load on the controller and he may be assisted by nomographs, charts, hand-held calculators, or other means of facilitating the task.

The other approach is with the controller operating basically as an extension of the computer. The computer sums the dose at time increments based on player location utilizing the existing PLS system. The controller using a prearranged code inputs observations on player vulnerability posture. The computer calculates cumulative doses and, at the time at which casualties would occur, flags the players for assignment of casualties.

2-5.9.3 Evaluation of Design Alternatives. Evaluation of alternatives for assessing and assigning delayed casualties are shown on Figure 2-33.

	RF EMITTER/ CONTROLLER	COMPUTER/ CONTROLLER
REALISTIC	2	3
TOTAL INCAPACITATION	4	4
ASSESSMENT CONSISTENT WITH INDICATION	3	4
TOTAL DOSE PROVIDED	2	4
TOTAL DOSE SINCE DOSIMETERS ZEROED	3	4
INCIPIENT CASUALTIES TAGGED	2	4
INPUTS TO AAR	2	4
NON-INTRUSIVE	3	4
R & D COST	4	3
PROCUREMENT COST	2	3
OPERATING COST	3	3
TOTAL SCORE	30	40

LEGEND: 4 EXCELLENT; 3 GOOD; 2 FAIR; 0 POOR

Figure 2-33. Evaluation of design alternatives for assessing and assigning delayed casualties

As shown in this figure the computer with inputs from the controller is far superior to the controller alone or the controller operating with the RF emitter. Assessing and assigning delayed casualties is such a large computational task that the controller will have great difficulty in performing it. This results in unrealistic assessment which may be inconsistent with the indication of capabilities. Without use of the computer, total dose may be unrealistic, there may be problems in keeping track of when dosimeters were last zeroed, and in tagging incipient casualties, plus a complicated way of inputting information to after action reviews, and an intrusive operation in which the controller is very much in evidence.

2-5.10 Design Alternatives for Indicating Delayed Casualties

2-5.10.1 Desired Characteristics are shown below:

- The indication should be realistic to the extent appropriate to training effectiveness and cost. Devices to add realism must be evaluated in terms of the actual training effectiveness achieved versus costs.

- The system should be non-intrusive so that players do not get unrealistic cues to assist them in identifying casualties.

- The system should be prompt, although promptness in indicating delayed casualties is not as important as in indicating initial casualties.

- Indication of casualties should be at an appropriate level. A step function which shows players as either casualties or not casualties is probably adequate.

- Delayed casualties will occur gradually and such gradual degradation would be desireable in the play of the problem but is probably not essential.

- Indications of radiation sickness symptoms which may interfere with the morale and consequent effectiveness of the players would be desireable but is probably not essential.

- The system should be safe.

- There should be no adverse environmental impact.

- The system should be low cost. Cost should be consistent with the training effectiveness contained.

2-5.10.2 Design Alternatives (Figure 2-34)

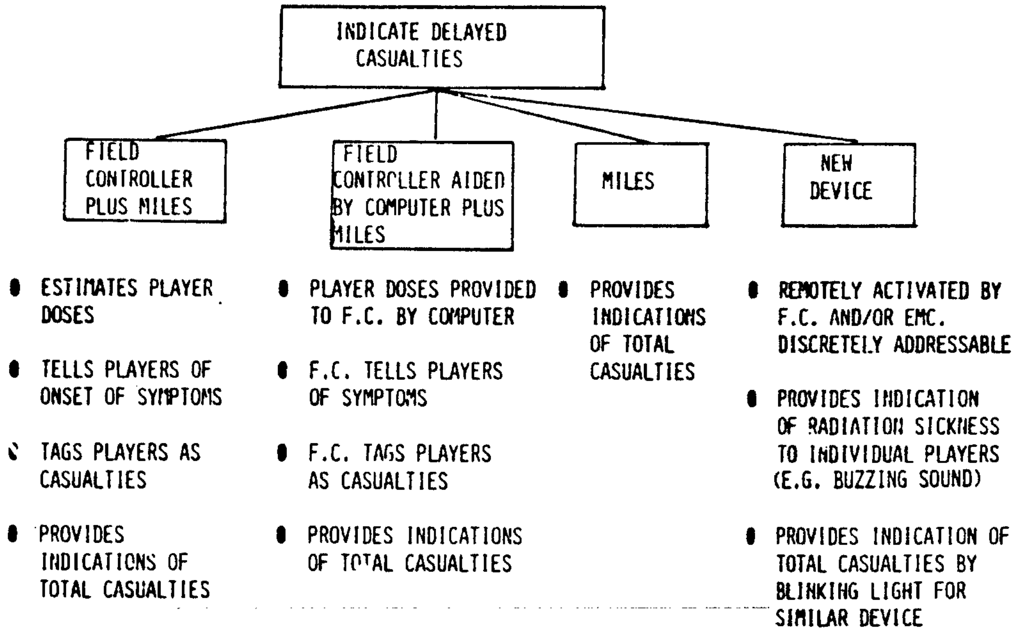


Figure 2-34. Design alternatives for indicating delayed casualties

The first approach is using the field controller plus MILES. In this case the field controller keeps track of the doses and using the MILES device assesses a total radiation kill by turning on the kill light on the B unit. In the second case the field controller operates in effectively the same way except that he is given the information by the computer as to the number of casualties to be indicated or specific units which should be indicated as casualties. The third alternative is using MILES alone. In this case MILES is activated remotely by the "A" station or by the field controller based on inputs from the computer. The fourth approach uses a new device which would be remotely activated by the field controller or by the "A" station using information from the computer. The device would be discretely addressable and provide both an indication of a total kill by means of a blinking light or some other more realistic indication to be determined in the future. This might be a notification through the intercom system telling the vehicle commander to shut off the engine and cease operations. The system would also provide an indication of radiation sickness to individual players. A loud buzzing sound over the intercom system could be used for this purpose and the irritating effects of the noise would not only be a signal to indicate radiation sickness but might also cause enough irritation to degrade players performance.

2-5.10.3 Evaluation of Design Alternatives Evaluation is shown in Figure 2-35.

	FIELD CONTROLLER (F.C.) PLUS MILES	F.C. AIDED BY COMPUTER PLUS MILES	MILES ALONE	NEW DEVICE
REALISM	0	3	0	3
NON-INTRUSIVE	0	0	4	4
PROMPT	2	2	4	4
INDICATES TOTAL CASUALTIES	4	4	4	4
INDICATES DEGRADATION	3	3	0	2
INDICATES SYMPTOMS	3	3	0	3
SAFE	3	3	4	4
NO ADVERSE ENVIRONMENTAL IMPACT	4	4	4	4
R & D COST	4	4	4	2
PROCUREMENT COST	4	4	4	2
OPERATING COST	3	3	4	3
TOTAL	30	33	32	35

LEGEND: 4 EXCELLENT, 3 GOOD, 2 FAIR, 0 POOR

Figure 2-35. Evaluation of design alternatives for indicating delayed casualties

As seen in this figure the alternatives were relatively close with the new device and the field controller aided by the computer having the highest scores. If the field controller is used to indicate degradation or symptoms, he will be intrusive since he would have to visit and communicate with each player effected. MILES alone does not have a capability for indicating degradation or symptoms. Therefore it appears that if degradation and symptoms of radiation sickness are desireable in the training exercise the only way to incorporate them in a non-intrusive manner is to use a new device.

2-5.11 Design Alternatives for Recording Radiation Levels and Delayed Casualties

This function consisted of software approaches which would need to be evaluated on the basis of impact on computer software and hardware. Desireable characteristics are as follows:

- Radiation rate contours should be recorded and displayed in steps of operational interest for controllers and for after action reviews. One step might be the level at which continuous monitoring is to occur. This is one rad per hour. Other rates of operational interest would be those which result in unacceptable doses if the unit operates in that area for a reasonable time. A still higher rate would be that which would require immediate departure from the area followed by decontamination.

- Total doses could be recorded and tagged in increments of operational interest for controllers and after action reviews. Maintaining doses incrementally rather than over a continuum would reduce the computational as well as storage requirements. Total doses of five rads constitute a negligible exposure, 50 rads a serious exposure (according to STANAG2083). Doses from zero to 70 rads result in less than 5% hospitalization and no fatalities. Examples of other doses of interest are as follows: 150 rads which produces symptoms within six hours consisting of reduced effectiveness, vomiting, and so on in approximately 5% of the personnel but no fatalities; 650 rads which produces symptoms within two hours in 100% of the people and results in more than half casualties in 16 days; 2000-3000 rads which results in symptoms within 5 minutes and 100% casualties within 7 days;8000 rads which produces symptoms within 5 minutes causing total incapacitation with no recovery. Selection of dose increments must also be consistent with requirements for reporting readings on dosimeters. Doses need to be recorded both for players inside tanks and APCs and ouside.

- Significant increases in dose rate for total doses due to nuclear burst or contamination need to be keyed to significant events in the after action review so that the performance of players can be evaluated at these critical times.

2-6 COMPUTATIONAL CONSIDERATIONS

This subsection provides certain computational considerations in evaluating computer based alternatives.

2-6.1 Overview of Computational Requirements

Figure 2-36 is an overview of computational requirements for each training function.

NTC NW TRAINING FUNCTIONS ↓	RADIATION RATES AS FUNCTION OF TIME & LOCATION	CONTAMINATION AS FUNCTION OF PLAYER & TIME	DOSE AS FUNCTION OF PLAYER & TIME	CASUALTIES
• INDUCED/FALLOUT RADIATION SIMULATION	C,D	--	C,D	--
• CONTAMINATION SIMULATION	C,D	C,D	C,D	--
• ASSESS, ASSIGN INITIAL CASUALTIES AND DOSES	--	--	C,D	C,S,D
• INDICATE INITIAL EFFECTS	--	--	C,D	C,D
• ASSESS, ASSIGN DELAYED CASUALTIES AND DOSES	C,D	--	C,D	C,S,D
• INDICATE DELAYED EFFECTS	C,D	--	C,D	C,D
• RECORD RADIATION LEVELS, DOSES, CONTAMINATION, CASUALTIES	C,S,D	C,S,D	C,S,D	C,S,D

C COMPUTE
S STORE
D DISPLAY

Figure 2-36. Computational requirements overview

Computational requirements consist of calculating radiation rates as a function of time and location, calculating contamination as a function of player and time, calculating dose as a function of player and time and calculating casualties. The matrix shows which of these calculations need to be performed for each function, the results that need to be stored, and results which need to be displayed. The overall requirement is the most demanding one in each column. As shown in the figure, results of all of the calculations need to be stored and displayed.

2-6.2 Desired Characteristics

Figure 2-37 shows desired characteristics of all computer approaches.

NO CLASSIFIED INFORMATION ON NTC COMPUTER

LOW DEVELOPMENT COSTS
- UTILIZE EXISTING SOFTWARE DESIGN CONCEPT (COMPUTATIONAL & IDC)
- UTILIZE EXISTING DATA BASES & STRUCTURES

MINIMAL HARDWARE IMPACT (THROUGHPUT, MEMORY, SECONDARY STORAGE)

LOW OPERATING COSTS

RELIABLE, AVAILABLE, MAINTAINABLE HARDWARE CONFIGURATION

PRODUCEABLE, RELIABLE, AVAILABLE, MAINTAINABLE SOFTWARE

SCENARIO FLEXIBILITY

USEABLE FOR CHEMICAL WARFARE

Figure 2-37. Desired characteristics of all computer approaches

There should be no classified information on the NTC computer since it would be very difficult to appropriately protect this information and it would greatly interfere with the normal operation of the NTC. Therefore, models must be sanitized or the results calculated off-line and furnished in an unclassified table lookup.

The design of the software should be such that there are not significant restrictions on the scenarios. The software should accomodate any reasonable nuclear warfare scenario.

Software approaches which can be used for chemical warfare are desireable since chemical warfare will probably be incorporated in the NTC at some future time.

Other characteristics in the figure are self-explanatory.

2-6.3 Computational Technique Considerations

Figure 2-38 shows considerations which will facilitate software design and reduce requirements on the computer.

- INITIAL EFFECTS, EXCEPT DOSE, ONCE ASSIGNED TO PLAYER CAN BE DROPPED FROM STORAGE EXCEPT FOR AAR NEEDS.
- FOR PLAYERS, INITIAL EFFECTS ARE OF INTEREST ONLY AT PLAYER LOCATION AND AT TIME OF BURST. CHANGES IN TERRAIN AND VEGETATION WOULD NEED TO BE STORED.
- CUMULATIVE DOSE FOR EACH PLAYER MUST BE UPDATED AND STORED.
- RADIATION RATE LEVELS ARE OF INTEREST FOR ALL POINTS IN EXERCISE AREA FOR ALL TIMES. IF KNOWN FOR ONE TIME CAN BE CALCULATED FOR OTHERS.
- RADIATION IS ONLY ENVIRONMENT REQUIRED IN NTC COMPUTER. OTHER PHENOMENA CAN BE STORED AS EFFECTS IN NTC COMPUTER.
- GRID-SIZE FOR STORAGE DEPENDS ON EFFECTS GRADIENT. VARIABLE GRID SIZE REQUIRES LESS STORAGE.

Figure 2-38. Computational technique considerations

Figure 2-39 shows four alternative computational approaches.

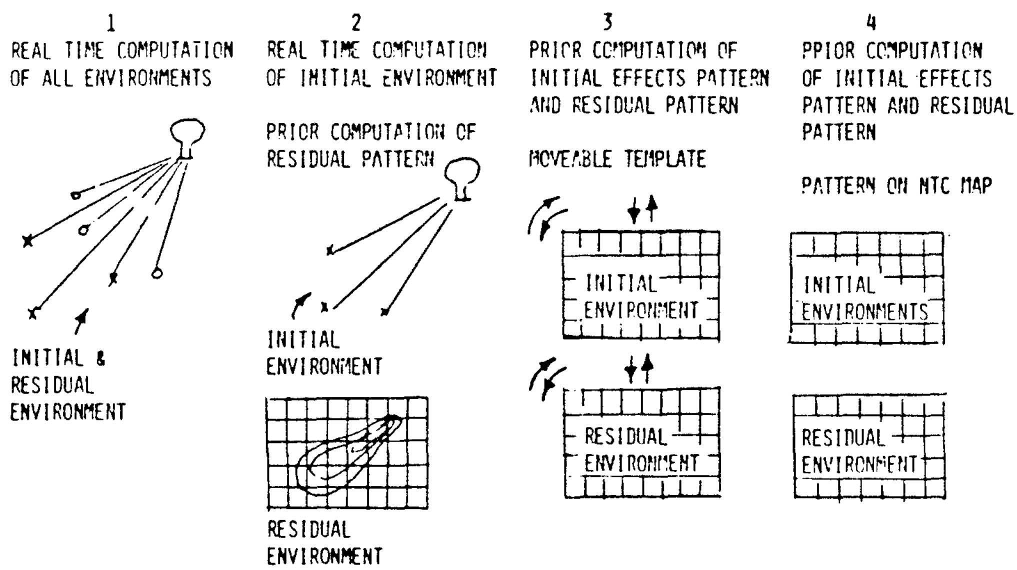


Figure 2-39. Alternative computer approaches

The first approach consists of real time computation in the computer of all environments. The second approach uses a stored grid pattern for residual environments. A third

approach uses grid patterns which are moveable for both initial environments and residual environments. The fourth approach uses grid patterns fixed to the map for both types of environments. This last approach requires that the location of the burst be known in advance but allows calculations to include such factors as terrain shielding. Figure 2-40 compares the computational techniques.

	ALL REAL TIME	INITIAL REAL-TIME, PRIOR COMPUTATION OF RESIDUAL	PRIOR COMP OF ALL EFFECTS ON MOVEABLE TEMPLATE	PRIOR COMP OF ALL EFFECTS ON NTC MAP
SECURITY	2	2	4	4
EXISTING PROGRAMS	2	3	4	4
EXISTING DATA BASES	2	3	4	4
CPU REQMT.	2	3	4	4
STORAGE REQMT.	4	3	2	2
I/O, DATA TRANSFER	4	3	2	2
MANPOWER	4	4	4	4
COMPUTER TIME	3	3	3	3
HARDWARE RAM	3	3	3	3
SOFTWARE PRAM	3	4	4	4
FLEXIBILITY	4	3	3	2
CHEM WARFARE	2	3	4	4
TOTAL SCORE	35	37	41	40

LEGEND: 4 EXCELLENT; 3 GOOD; 2 FAIR; 0 POOR

Figure 2-40. Comparison of computational techniques

As shown in this figure the use of a moveable template appears to be the best approach. Figure 2-41 shows the storage estimates for such a grid approach.

WORST CASE: 12.5 METER GRID SQUARE

10 X 15 KM AREA

10 WEAPONS

20 M BYTES

MASTER TABLE: SOME GRIDS ARE SAME

4 M BYTES

VARIABLE SIZE GRID: 1 KT 12.5 TO 1000 M GRID SIZE

50 KT 50 TO 1000 M GRID SIZE

2 M BYTES

Figure 2-41. Storage estimates for a grid approach

These requirements are reasonable and attainable.

2-6.4 Computer Display Considerations

Figure 2-42 shows the graphics and alpha-numerics displays required for each training function and also shows additional analysis required.

TRAINING FUNCTION	GRAPHICS	ALPHANUMERICS	ADDITIONAL ANALYSIS REQUIRED
• INDUCED/FALLOUT RADIATION SIMULATION	• RADIATION RATE CONTOURS	• RADIATION RATE AT DESIGNATED LOCATION	• CONTOUR INTERVALS AND UPDATE FREQUENCY
• CONTAMINATION SIMULATION	• DECONTAMINATION AREA	• DOSES • DOSE RATES • PENALTIES	• UPDATE FREQUENCY • SMALLEST UNIT SIZE (E.G. PLATOON)
• ASSESS/ASSIGN INITIAL CASUALTIES	• DAMAGE CONTOURS (OPTIONAL)	• PLAYER CASUALTIES & PHENOMENA • INITIAL DOSES	• PHENOMENA (E.G. BLAST, THERMAL) TO BE INCLUDED
• INDICATE INITIAL CASUALTIES AND DOSES	• GRAPHIC CUES FOR KILLS	• CASUALTIES TO BE INDICATED • CASUALTIES INDICATED • DOSES	• PHENOMENA TO BE SHOWN • SMALLEST UNIT SIZE FOR DOSES
• ASSESS/ASSIGN DELAYED CASUALTIES	• FALLOUT/INDUCED CONTOURS	• PLAYER CASUALTIES • PLAYER TOTAL DOSES • INCIPIENT CASUALTIES	• METHOD FOR INCIPIENT CASUALTIES • CONTOUR INTERVALS AND UPDATE FREQUENCY
• INDICATE DELAYED CASUALTIES AND DOSES	• FALLOUT/INDUCED CONTOURS	• CASUALTIES TO BE INDICATED • CASUALTIES INDICATED • DOSES	• CONTOUR INTERVALS AND UPDATE FREQUENCIES • SMALLEST UNIT SIZE FOR DOSES
• RECORD RADIATION LEVELS, DOSES, CONTAMINATION, CASUALTIES	• RADIATION RATE CONTOURS AT KEY TIMES • CASUALTY CIRCLES AT KEY TIMES	• DOSE LEVEL BY UNITS AT SELECTED TIMES • CONTAMINATION OF UNITS AT SELECTED TIMES	• CONTOUR INTERVALS • CASUALTY PHENOMENA TO BE INCLUDED • SMALLEST UNIT SIZE FOR DOSES

Figure 2-42. Computer display considerations

SECTION 3
CONCLUSIONS

3-1 SUMMARY OF CONCLUSIONS IN DERIVATION OF THE TRAINING SYSTEM

This sub-section summarizes the conclusions reached in the derivation of the training system design. The next sub-section summarizes the recommended design.

	Subject	Conclusions
3-1.1	Training Requirements	The NTC Nuclear Warfare Training System design should be based on the eight following situations: • Prepare for operations in a nuclear environment • Prepare for nuclear attack • React to initial nuclear effects • React to delayed effects • Cross or operate in a contaminated area • Conduct a radiological reconnaisance • Prepare for a Blue Force nuclear strike • Decontaminate
3-1.2	Training Functions	Training functions to be incorporated in the design are as follows. The recommended design approach for each function is provided. In some cases an alternate design approach is provided.
3-1.2.1	Stimulate Players via Nuclear Burst Simulation	Design a new simulator which provides • An air burst • Two pulse visual radiation • Two pulse audible radiation • White mushroom cloud
3-1.2.2	Stimulate Players via Delayed Effects Simulation	Preferred approach: • Computer calculates and stores radiation patterns and player doses • Information provided players via addressible radio receivers (to be designed which simulate IM 174/IM174A radiometers.)

- Provide similar means for simulating dosimeters.

Alternate approach:
Continue using AN/TBQ-T1(V) but store patterns in computer. Calculate and store player doses. Provide doses to field controllers.

3-1.2.3	Stimulate Players via Contamination Simulation	Preferred approach: Calculate and store contamination levels in computer. Alert controller to contaminated units. Provide consistent radiation rates and doses. Store and use information from field controllers on decontamination procedures. Compute changes in radiation rates and doses. Alternate approach: (Only to be considered with alternate approach in 3-1.2.2) Develop RF emitter to be mounted on vehicles which is consistent with meters in AN/TBQ-T1(V). Emitter to be turned on by addressable RF link.
3-1.2.4	Assess and Assign Initial Casualties	Computer calculates and stores initial casualties due to each phenomenon and initial radiation dose. Assignment includes inputs from field controllers on vulnerability posture.
3-1.2.5	Indicate Initial Casualties	Preferred approach: Indicate only total casualties; no degradation. Also record initial radiation dose. Indicate total casualties using MILES kill indication light activated by field controller or A station, as directed by controllers guided by computer input. Alternate approach: Develop a new simulator which also has a capability to indicate to affected player the effects of degradation due to radiation.

3-1.2.6	Assess and Assign Delayed Casualties	Casualties are assessed by computer which stores total doses for players. Field controllers furnish information on vulnerability posture and shielding. Computer indicates when potential casualties have reached the time when incapacitation would occur for a given dose. Total doses are also furnished at end of exercise for all players as part of AAR.
3-1.2.7	Indicate Delayed Casualties	Preferred approach: Field controller informs platoon leaders of radiation sickness symptoms troops are experiencing. Kills are indicated based on percent of casualties expected. Field controller activates kill lights using MILES. Computer provides guidance on numbers of casualties on each platoon. Alternate approach: Develop new device which provides indication of radiation sickness directly to player. Also look into possibility of degrading effectiveness by varying the MILES instrumentation to reduce accuracy of weapons of crews with radiation sickness.
3-1.2.8	Record Radiation Levels and Casualties	Use computer to calculate, store, update radiation rate contours. Use computer to calculate, store, update total doses at some appropriate level from individual to platoon. Key significant changes in dose rates or total doses to events for use in AAR.
3-1.2.9	Software and Scenario Testing	Design and install a nuclear warfare testbed for use in developing software procedures for NTC NW and to test nuclear warfare related scenarios.

3-2 RECOMMENDED DESIGN

Recommended changes to the NTC to provide an integrated nuclear warfare training system are shown in Figure 3-1.

ELEMENT	PURPOSE
ADDITIONAL SOFTWARE	PROVIDE DOSE, DOSE RATE, CASUALTIES AND STATISTICS COMPUTATIONS AS WELL AS NW INTERACTIVE DISPLAY AND CONTROL CAPABILITIES
ALLOCATION OF NUCLEAR WARFARE POSITION IN EMC/TAF	CONTROL, MONITORING, EVALUATION, FEEDBACK OF NUCLEAR EMPLOYMENT AND EFFECTS
NEW BURST FIELD SIMULATOR	STIMULATE PLAYERS (BURST CUE)
NEW ADDRESSIBLE, COMPUTER DRIVEN RADIAC METER AND DOSIMETER SIMULATORS	STIMULATE PLAYERS (INSTRUMENTATION MEASUREMENT CUE)
AUGMENTATION OF FIELD CONTROLLERS WITH CHECK LISTS, PROCEDURES, TRAINING	OBSERVATION, EVALUATION REPORTING OF NUCLEAR VULNERABILITY POSTURE AND ACTIVITIES. ASSIST IN INDICATING CASUALTIES

Figure 3-1. Recommended changes to NTC for nuclear warfare training

These changes consist of additional software, allocation of certain hardware to the nuclear warfare training functions, development and procurement of new hardware and augmentation of personnel by providing them with checklists, procedures, training, and equipment to facilitate the performance of additional duties.

Figure 3-2 shows the summary of the NTC operational concept which explains the interaction between the components.

CIS SOFTWARE • NW RTCA • NW FIELD INSTRUMENTATION CONTROL • NW IDC	• RAD RATES • DOSES • CASUALTIES • LOCATIONS • CONDITION		• AUTOMATED CONTROL OF BURST (OPTION) OUT	• RAD RATES • DOSES	• ADMINISTRATIVE KILL
• REQUEST DISPLAYS • CONTROL PARAMETERS • OBSERVATIONS	CIS CONTROLLER • ETIC • TAF • ROLEPLAYING	• RAD RATES • DOSES • CASUALTIES • FIELD CONTROLLER DIRECTION	IN OUT	IN	• HIGHER/ADJCT HQ INFO • AAR
	• EVALUATION • OBSERVATIONS • DATA/CONTL REQUESTS	FIELD CONTROLLER AUGMENTED BY TRAINING, CHECKLISTS, REPORTING CODES	• CONTROL BURST		• ASSIST IN CASUALTY INDICATION • ASSESS CASUALTIES
		• STATUS	FIELD CUE SIMULATOR NUCLEAR BURST SIMULATOR		• BURST STIMULUS
• POSITION • STATUS • ENGAGEMENT EVENTS • CUMMO EVENTS		• MEASUREMENT OBSERVATIONS		FIELD INSTRUMENTATION • POSITION/LOCATION • MILES • RADIAC SIM • DOSIMETER SIM	• RAD RATES • DOSES • CASUALTIES
	• INFO TO HIGHER/ADJCT UNITS	• ORDERS • PROCEDURES • ACTIONS		• MEASUREMENT PROCEDURES • PLAYER ACTIONS	PLAYERS • CMD • STAFF • SPECIALISTS • TROOPS

Figure 3-2. Summary of recommended NTC nuclear warfare operational concept

In the figure, components are shown in the diagonal elements of the metrics. These components are: CIS software, CIS controller, field controller, field cue simulator, field instrumentation and players. In the row with each diagonal element are shown outputs from that element. For example, the outputs from CIS software (in the first square to the right) are radiation rates, doses casualties, locations, and conditions. Inputs to each component are shown in the vertical column associated with that component. For example, the inputs to the CIS controller from the CIS software are shown in the square above the CIS controller and to the right of the CIS software. These inputs are: rad rates, doses, casualties, locations, and condition.

From the figure it is seen, for example, that the CIS software outputs to the CIS controller, to the field cue simulator, to the field instrumentation, and to the players. Inputs to the CIS software are from the CIS controller and from the field instrumentation.

Figure 3-3 shows the current area in which two- sided field exercises are conducted at the NTC at Fort Irwin.

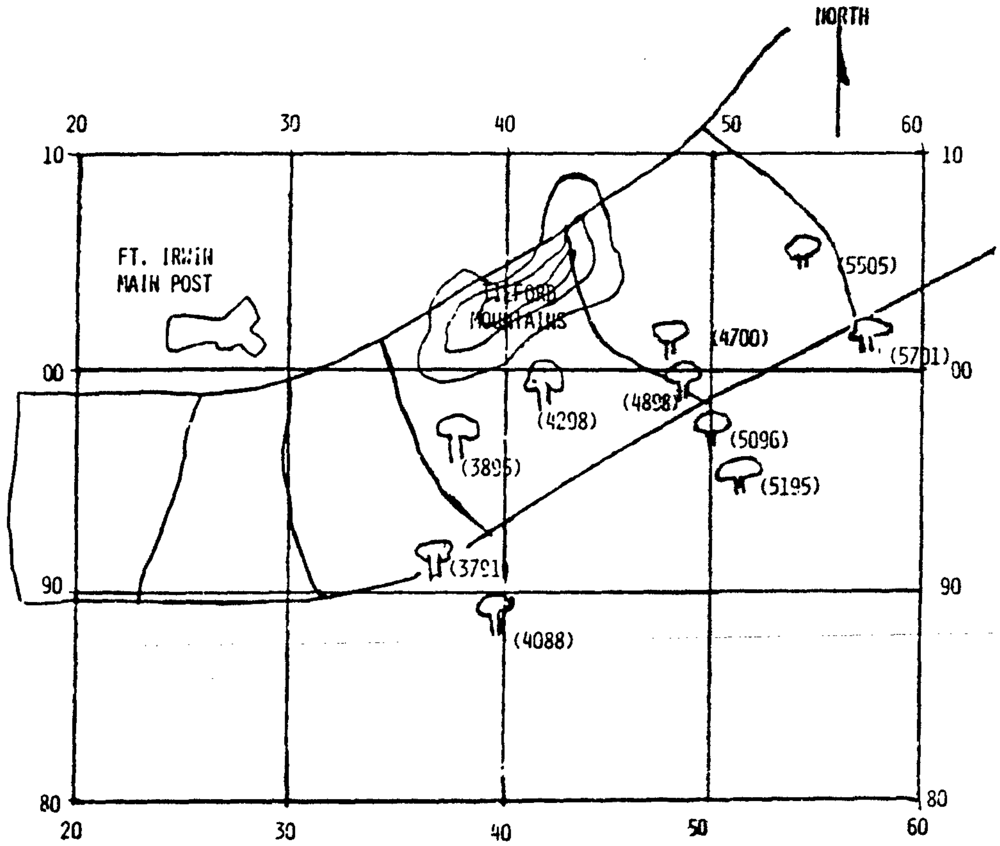


Figure 3-3. Potential nuclear simulator sites in rear areas and adjacent units

Each square represents 10 kilometers. The mushroom cloud symbols show where simulated nuclear bursts have been used, or can be used, in various phases of the exercise. These nuclear bursts would be in the rear of the maneuvering elements or in simulated adjacent units. A north arrow is shown on the map. The prevailing wind about 10 months of the year is from west to east and for about 2 months of the year is from south to north. However, local winds vary considerably and can change rather rapidly. This figure is based on conversations with members of the Army Operations Group at Fort Irwin. It illustrates that there is room and appropriate terrain for the operational concept as recommended.

SELECTED BIBLIOGRAPHY

1. ARTEP 71-2 (Draft), Army Training and Evaluation Program, Hq. DA, undated

2. FM 3-12 Operational Aspects of Radiological Defense, Hq. DA, 21 August 1968

3. FM 3-22, Fallout Prediction, Hq. DA, 30 October 1973

4. FM 3-87, "Nuclear Biological and Chemical (NBC) Reconnaissance and Decontamination Operations", Hq. DA, 22 February 1980

5. FM 7-20, The Infantry Battalion, Hq. DA, 3 April 1978

6. FM 21-40, Chemical, Biological, Radiological and Nuclear Defense, Hq. DA, 14 October 1977

7. FM 71-2, The Tank and Mechanized Infantry Task Force, Hq. DA, 30 June 1977

8. FM 100-5, Operations, Hq. DA, 1 July 1976

9. FM 101-31-1, Nuclear Weapons Employment Doctrine and Procedures, 21 March 1977

10. FM 101-31-3, Nuclear Weapons Employment Effects Data, 30 June 1977

11. The Effects of Nuclear Weapons, DOD/ERDA, Washington, D.C., 1977

DISTRIBUTION LIST

DEPARTMENT OF DEFENSE

Armed Forces Radiobiology Rsch Institute
Defense Nuclear Agency
ATTN: Director
ATTN: DD
ATTN: SD

Armed Forces Staff College
ATTN: Library

Assistant to the Secretary of Defense
Atomic Energy
ATTN: J. Wade
ATTN: Mil Appl, W. Kahn
ATTN: R. Wagner

Command & Control Technical Center
ATTN: C-312, R. Mason

Defense Advanced Rsch Proj Agency
ATTN: TTO

Defense Communications Agency
ATTN: Code J300, M. Scher

Defense Nuclear Agency
ATTN: STNA
ATTN: NASD
ATTN: NATD
ATTN: STBE
ATTN: NAFD
4 cy ATTN: TITL
4 cy ATTN: NATA

Defense Technical Information Center
12 cy ATTN: DD

Deputy Under Sec of Def
ATTN: T. Jones

Field Command
DNA, Det 1
Lawrence Livermore Lab
ATTN: FC-1

Field Command
DNA, Det 2
Los Alamos National Lab
ATTN: MS-635, FC-2

DNA PACOM Liaison Office
ATTN: J. Bartlett

Field Command
Defense Nuclear Agency
ATTN: FCTT, S. Humpries
ATTN: FCTXE
ATTN: FCPR

Interservice Nuclear Weapons School
ATTN: Document Control

Joint Chiefs of Staff
ATTN: J-3, Strategic Operations Division
ATTN: J-5, Nuclear Division/Strategy Div
ATTN: J-5 Nuc/Chem Plcy Br, J. Steckler

DEPARTMENT OF DEFENSE (Continued)

National Defense University
ATTN: NWCLB-CR

Principal Dep Under Sec of Defense
ATTN: J. Wade, Jr

Under Secy of Def for Rsch & Engrg
ATTN: R. Delauer
ATTN: Strat & Arms Control, L. Menichiello
ATTN: K. Hinman

DEPARTMENT OF THE ARMY

Dep Ch of Staff for Ops & Plans
ATTN: DAMO-RQS
ATTN: DAMO-NON
ATTN: DAMO-RQA, Firepower Div
5 cy ATTN: DAMO-NC, Nuc Chem Dir

Harry Diamond Laboratories
ATTN: DELHD-NP
ATTN: 00100 Commander/Tech Dir/Div Dir
ATTN: DELHD-DE
ATTN: DELHD-TD, Tech Dir
ATTN: DELHD-NW-P

US Army Armament Rsch Dev & Cmd
ATTN: DRDAR-LCN-E

US Army Ballistic Research Labs
ATTN: R. Reisler
ATTN: DRDAR-BLV
ATTN: DRDAR-BLA-S

US Army Chemical School
ATTN: ATZN-CM-CC

US Army Comd & General Staff College
ATTN: DTAC
3 cy ATTN: Combined Arms Research Library
3 cy ATTN: ATZZL-CAD-LN

US Army Engineer School
ATTN: Library

US Army Engr Waterways Exper Station
ATTN: J. Houston

US Army Forces Command
ATTN: AF-OPTS

US Army Infantry Ctr & Sch
ATTN: ATSH-CD-OSO

US Army Intelligence Center & School
ATTN: ATSI-CD-CS

US Army Logistics Center
ATTN: ATCL-OSS, S. Cockrell

US Army Materiel Dev & Readiness Cmd
ATTN: DRCDE-D

US Army Materiel Sys Analysis Actvy
ATTN: X5, W3JCAA

DEPARTMENT OF THE ARMY (Continued)

US Army Mobility Equip R&D Cmd
ATTN: DRDME-WC, Technical Lib

US Army Nuclear & Chemical Agency
ATTN: MONA-OPS
ATTN: MONA-OPS, B. Thomas
ATTN: Library
ATTN: MONA-OPS, J. Ratway

US Army TRADOC Sys Analysis Actvy
ATTN: ATAA-TAC

US Army Training and Doctrine Comd
ATTN: ATCD-FA
5 cy ATTN: ATT6-C

US Army War College
ATTN: War Gaming Facility
ATTN: Library
ATTN: AWCAC, F. Braden, Dept of Tactics

USA Military Academy
ATTN: Document Library

USA Missile Command
ATTN: DRSMI-YDR
ATTN: DRSMI-RH

USAFACFS
ATTN: ATZR-MG

DEPARTMENT OF THE NAVY

Marine Corps
ATTN: DCS, P&O Requirements Div
ATTN: Code 0100-31

Marine Corps Dev & Education Command
ATTN: Commander

Naval Air Force
US Atlantic Fleet
ATTN: Commander

Naval Civil Engineering Laboratory
ATTN: Code L-51, S. Johnson

Naval Postgraduate School
ATTN: Code 56PR
ATTN: Code 1424 Library

Nuclear Weapons Tng Group, Atlantic
ATTN: Nuclear Warfare Department

Nuclear Weapons Tng Group, Pacific
ATTN: Nuclear Warfare Department

Naval War College
ATTN: Code E-11, Tech Service

DEPARTMENT OF THE AIR FORCE

Air Force Propulsion Lab
ATTN: LKDH Stop 24, E. Haberman

Air University Library
ATTN: AUL-LSE

DEPARTMENT OF THE AIR FORCE (Continued)

Strategic Air Command
ATTN: SAC/IN

US Air Force Academy Library
ATTN: Library

OTHER GOVERNMENT AGENCIES

National Security Council
ATTN: H. Nau
ATTN: A. Myer
ATTN: G. Kemp
ATTN: R. McFarland
ATTN: R. Linhard
ATTN: W. Clark
ATTN: M. Guhin

NORAD
ATTN: J5YS, F. Smith

Office of Technology Assessment
ATTN: M. Harris

The White House
ATTN: Counsellor to the President, E. Meese

DEPARTMENT OF ENERGY CONTRACTORS

University of California
Lawrence Livermore National Lab
ATTN: L-21, M. Gustavson
ATTN: L-8, F. Barrish
ATTN: L-389, R. Andrews
ATTN: L-35, J. Immele
ATTN: R. Werne

Los Alamos National Laboratory
ATTN: M/S634, T. Dowler
ATTN: R. Stolpe
ATTN: R. Sandoval

Sandia National Laboratories
ATTN: 0332, J. Keizur
ATTN: Tech Lib 3141
ATTN: 0333, R. Stratton
ATTN: 0334, J. Struve

DEPARTMENT OF DEFENSE CONTRACTORS

Abbott Associates, Inc
ATTN: R. McLaurin

BDM Corp
ATTN: J. Braddock
ATTN: L. Schlipper

BDM Corp
ATTN: D. Peercy

Caci, Inc Federal
ATTN: A. Berry

Harold Rosenbaum Associates, Inc
ATTN: H. Rosenbaum

Inst for Foreign Pol Anal, Inc
ATTN: R. Faltzgraph
ATTN: J. Record

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

Institute for Defense Analyses
ATTN: D. Moody
ATTN: Classified Library
ATTN: V. Utgoff

International Energy Associates, Inc
ATTN: L. Scheinman

Kaman Tempo
ATTN: DASIAC
ATTN: C. Anderson

Kaman Tempo
ATTN: R. Miller

Kaman Tempo
ATTN: DASIAC

Leon Sloss Associates, Inc
ATTN: L. Sloss

University of Miami
ATTN: Contract Office, S. Wang

Natl Institute for Public Policy
ATTN: C. Gray

Orion Engineering, Inc
ATTN: W. Parks

Pacific-Sierra Research Corp
ATTN: H. Brode, Chairman SAGE

Palomar Corp
ATTN: C. Feldbaum
5 cy ATTN: B. Glaser
5 cy ATTN: B. Garrett

DEPARTMENT OF DEFENSE CONTRACTORS (Continued)

R&D Associates
ATTN: P. Haas

Rand Corp
ATTN: P. Davis

Rand Corp
ATTN: B. Bennett

Science Applications, Inc
ATTN: C. Burgart
ATTN: J. Martin
ATTN: M. Drake
4 cy ATTN: D. Erickson
4 cy ATTN: J. Ickler
4 cy ATTN: I. Osofsky

Science Applications, Inc
ATTN: B. Dial

Science Applications, Inc
ATTN: W. Layson
ATTN: J. Goldstein
ATTN: J. McGahan
ATTN: P. Setty
ATTN: W. Zimmerman

SY Corp
ATTN: S. Weiss

Titan Systems, Inc
ATTN: C. Albo

Physical Research, Inc
ATTN: K. Schwartz